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Senior Design Report, Watermelon Washer/Cutter

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This project's goal was to design and manufacture a mechanical device that could potentially be sold as a household product to help facilitate washing, cutting and serving large watermelons and other produce with requiring minimal set-up and break-down time.

MEMS 411

Senior Design

Watermelon I

Watermelon Washer and Cutter

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John Jedlicka

Department of Mechanical Engineering and Materials Science

School of Engineering and Applied Science

Washington University in Saint Louis

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1 Introduction

1.1 Project Problem Statement

The project problem as listed on the course website is the following:

6. Watermelon Washer \ Server: This is for bigger watermelons, which are difficult to handle when washing the rind prior to cutting. Design a system that facilitates (1) washing the rind before cutting; (2) Cutting the first disk from the melon; (3) Catching the two “halves” after cutting the first disk; (4) Sealing the exposed surface of the two halves as is now commonly done with plastic wrap; and (5) storing the “started” watermelon in the refrigerator.

1.2 List of Team Members

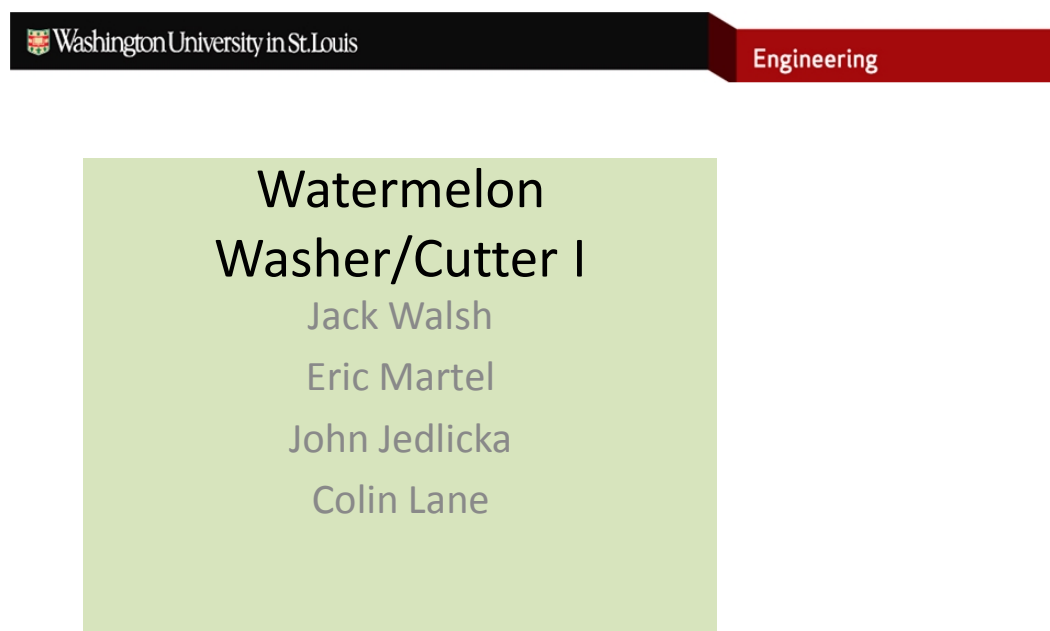


Figure 1.2.1-List of Team Members

2 Background Information Study

2.1 A short design brief description that defines and describes the design problem

The goal of this project is to develop and manufacture a watermelon washer and cutter that could potentially be sold as a household product to the public. The product must facilitate (1) washing the rind before cutting; (2) Cutting the first disk from the melon; (3) Catching the two “halves” after cutting the first disk; (4) Sealing the exposed surface of the two halves as is now commonly done with plastic wrap; and (5) storing the “started” watermelon in the refrigerator.

2.2 Summary of relevant background information (such as similar existing devices or patents, patent numbers, URL's, et cetera)

The results from the background information study showed that there were not many existing similar products for washing and processing watermelons and other produce. We found the following patents and other relevant information during the search.

Patents

There was only one patent we found related to “watermelon cutting.”

<https://patents.google.com/patent/US20110296695A1/en>

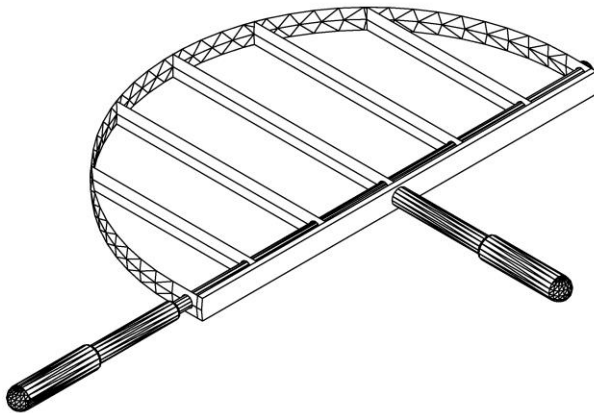


Figure 2.1.1 – Patent No. US20110296695A1, Watermelon Cutter

Miscellaneous Information

The following helped the group generate some ideas for cutting watermelons in new or unique ways. The following URL's are to videos that contain “watermelon cutting tips” and other related information.

- <https://youtu.be/D68Lck4Y5Ig>
- <https://youtu.be/fhrXxUj3T2o>
- https://youtu.be/heNDv1_QaKM

3 Concept Design and Specification

3.1 User needs, metrics, and quantified needs equations. This will include three main parts:

3.1.1 Record of the user needs interview

Project/Product Name: Watermelon Washer and Server			
Customer: Professor Jakiela		Interviewer(s): Colin Lane, Jack Walsh, Eric Martel, John Jedlicka	
Address: Washington University		Date: 9/10/15	
Willing to do follow up? Yes			
Type of user: Frequent User		Currently uses: Hands/Sink	
Question	Customer Statement	Interpreted Need	Importance
How big is the first disc cut?	At least 1" but could vary	Adjustable Cut (1" minimum)	5
How much are you willing to spend?	\$50.00	Device is Affordable.	5
How long does washing/cutting take normally?	20-25 minutes	Process complete in reasonable time.	5
Where is ideal storage location?	Shelf, cabinet or drawer.	Easily Stored	3
Should device accommodate variable melon sizes?	Yes, for different times of year	Adjustable length/accommodates variable sizes.	5
How messy is your current method?	Water and Juice goes everywhere.	Minimizes mess.	5
How do you store your cut melon?	Plastic wrapped and in bowl.	Post cut storage ease.	5
Where would you like to use this device?	Indoor Outdoor Use.	Device easily used inside and outside.	3
Who can operate this device?	Anyone above 10-12.	Safe and requires little strength.	5

3.1.2 List of identified metrics

Need Number	Need	Importance
1	WWC cuts 1" slice minimum	5

2	WWC is affordable	5
3	WWC washes, cuts and assists storing quickly	5
4	WWC is easily stored	3
5	WWC is easily cleaned	3
6	WWC adjusts for variable melon size	5
7	WWC minimizes mess	5
8	WWC facilitates washing the melon	5
9	WWC assists in cut melon storage	4
10	WWC can be used indoor and outdoor	3
11	WWC is easily operated	5

3.1.3 Metrics Table for Watermelon Washer and Cutter

Metric Number	Associated Needs	Metric	Units	Min Value	Max Value
1	4,6,10,11	Length	in	13	24
2	4,5,6,10,11	Volume	in ³	390	2400
3	3,5,7,8,9,11	Time	minutes	1	20
4	4,5,10,11	Number of sharp edges	Integer	1	5
5	2	Cost	US Dollars	20	50
6	1	Size of First Cut Disc	in	1	3
7	4,5,9,10,11	weight	lbs	3	10
8	2,3,6,11	Strength of Device	lbf	25	100
9	2,11	Durability	Integer	20	100
10	2,3,4,5,11	Number of Assembly Parts	Integer	1	10

3.1.3 Table/list of quantified needs equations

Watermelon Washer and Cutter Concept 4		Metric										Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
		Length	Volume	Time	# of Sharp Edges	Cost	Size of First Disc	Weight	Strength of Device	Durability	# of Assembly Parts			
Need#	Need	1	2	3	4	5	6	7	8	9	10			
1	Cuts 1" Slice						1					0	0.1041667	0
2	Affordable					0.8			0.067	0.067	0.066	0	0.1041667	0
3	Quick use			0.6					0.1		0.3	0	0.1041667	0
4	Easily Stored	0.05	0.5		0.05			0.25			0.15	0	0.0625	0
5	Easily Cleaned		0.3	0.4	0.1			0.1			0.1	0	0.0625	0
6	Adjustable Use	0.34	0.33						0.33			0	0.1041667	0
7	Minimizes Mess			1								0	0.1041667	0
8	Facilitates Washing			1								0	0.1041667	0
9	Assist Melon Storage			0.8				0.2				0	0.0833333	0
10	Indoor Outdoor	0.25	0.25		0.25			0.25				0	0.0625	0
11	Safely and Easily Operated	0.1	0.1	0.1	0.2			0.1	0.2	0.1	0.1	0	0.1041667	0
Units		in	in^3	minutes	integer	Dollars	in	lbs	lbf	Integer	Integer	Total Happiness		0
Best Value		13	390	1	1	20	1	3	100	100	1			
Worst Value		24	2400	20	5	50	3	10	25	20	10			
Actual Value														
Normalized Metric Happiness														

Figure 3.1.3.1- Quantified Needs Equations

3.2 Four (4) concept drawings

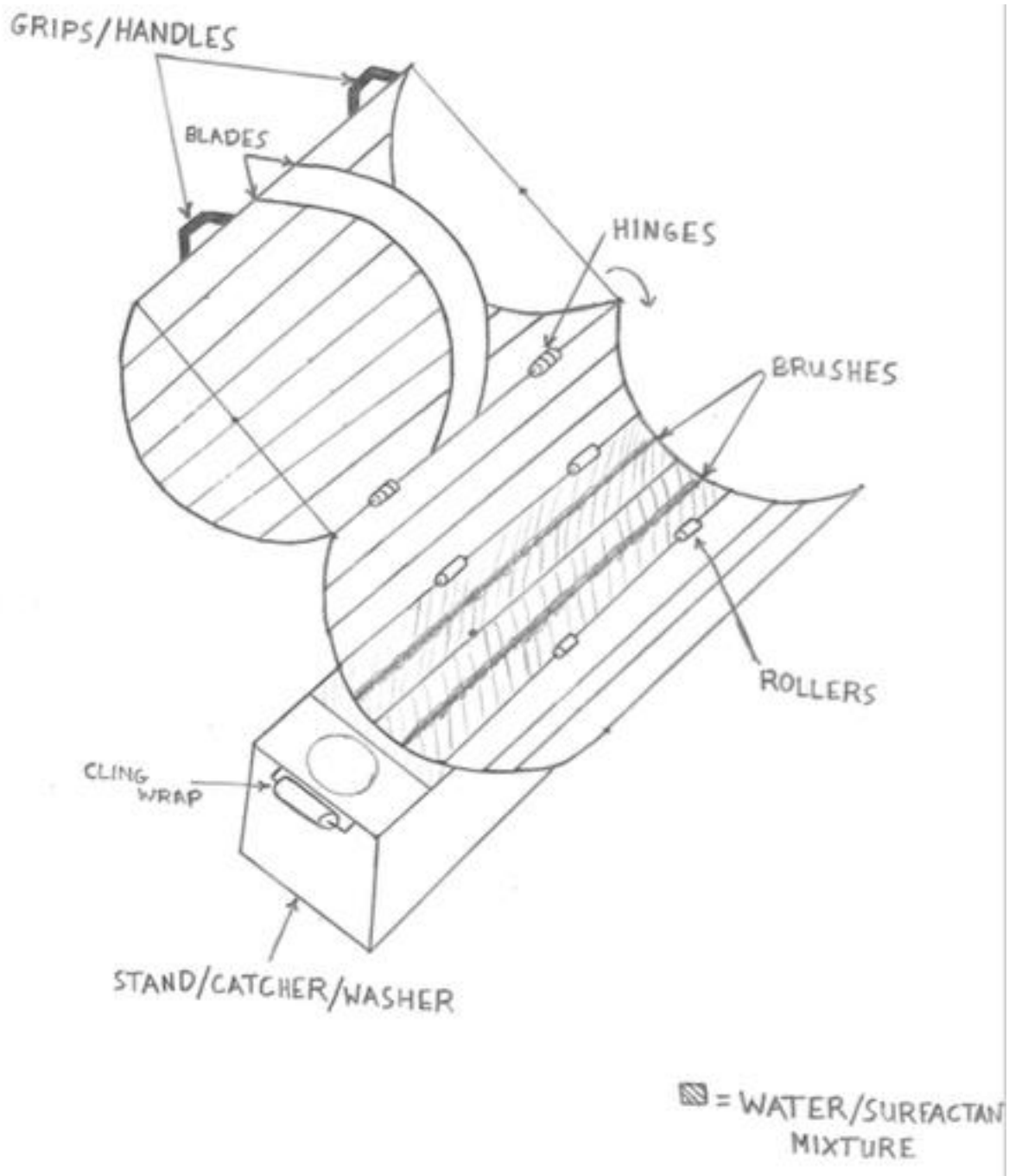


Figure 3.2.1- Concept 1-Watermelon Barrel

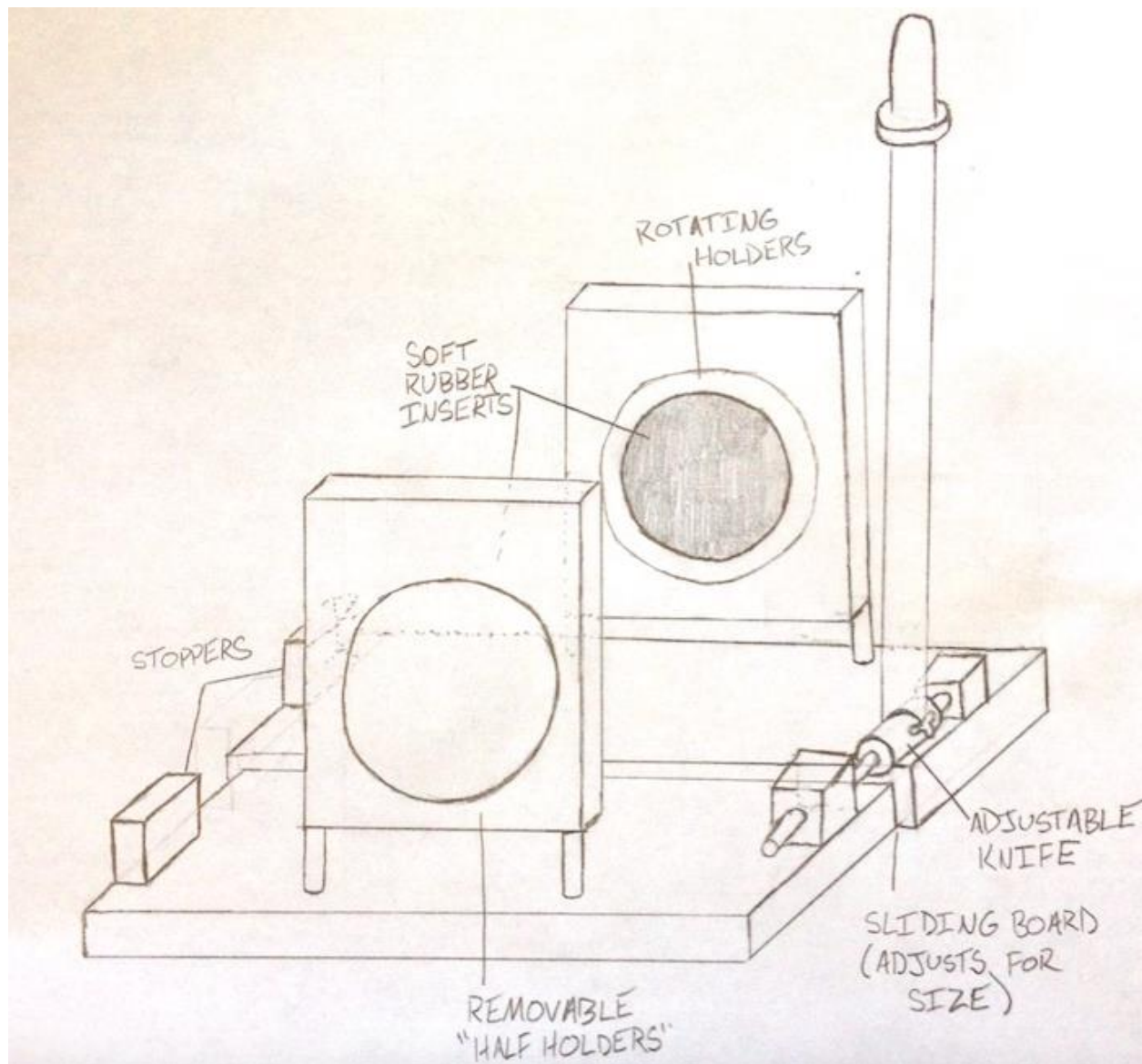


Figure 3.2.2-Concept 2-Sliding Cutting Board

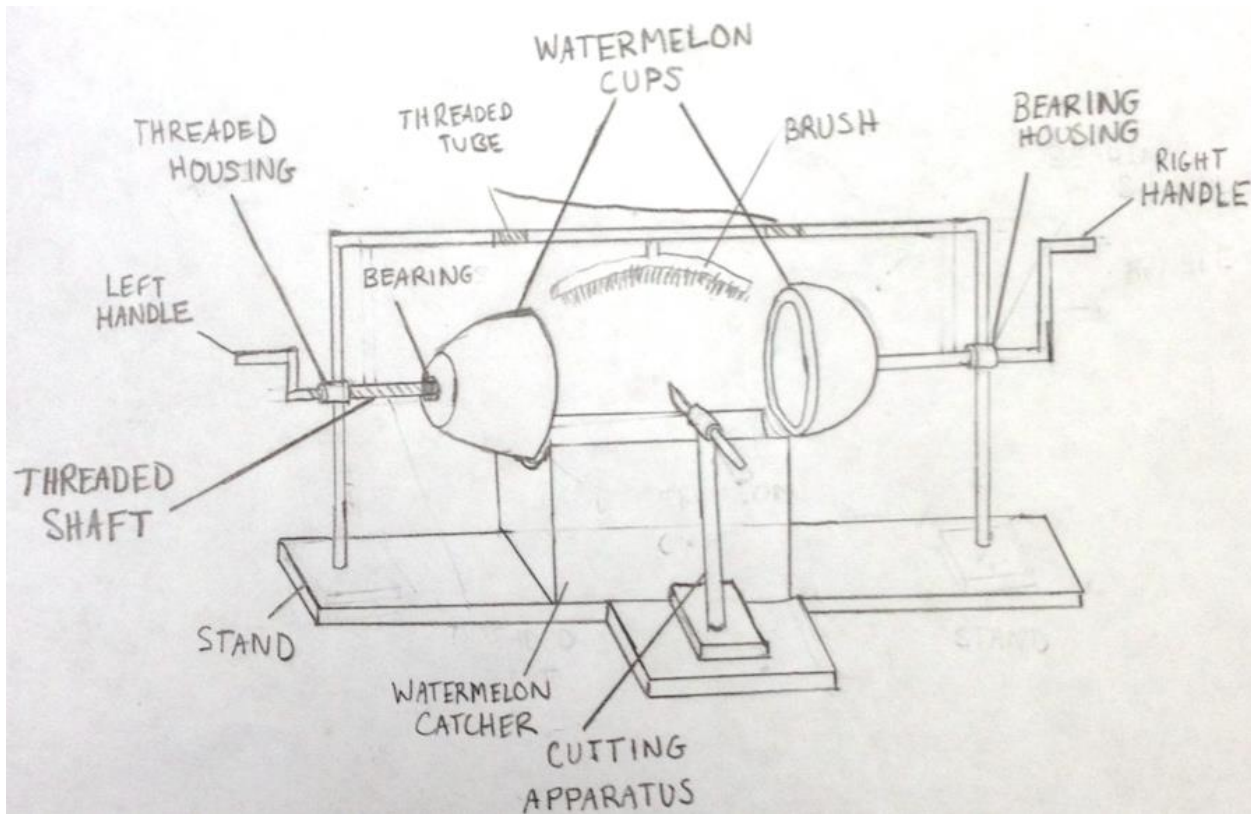


Figure 3.2.3-Concept 3-Suspended Watermelon

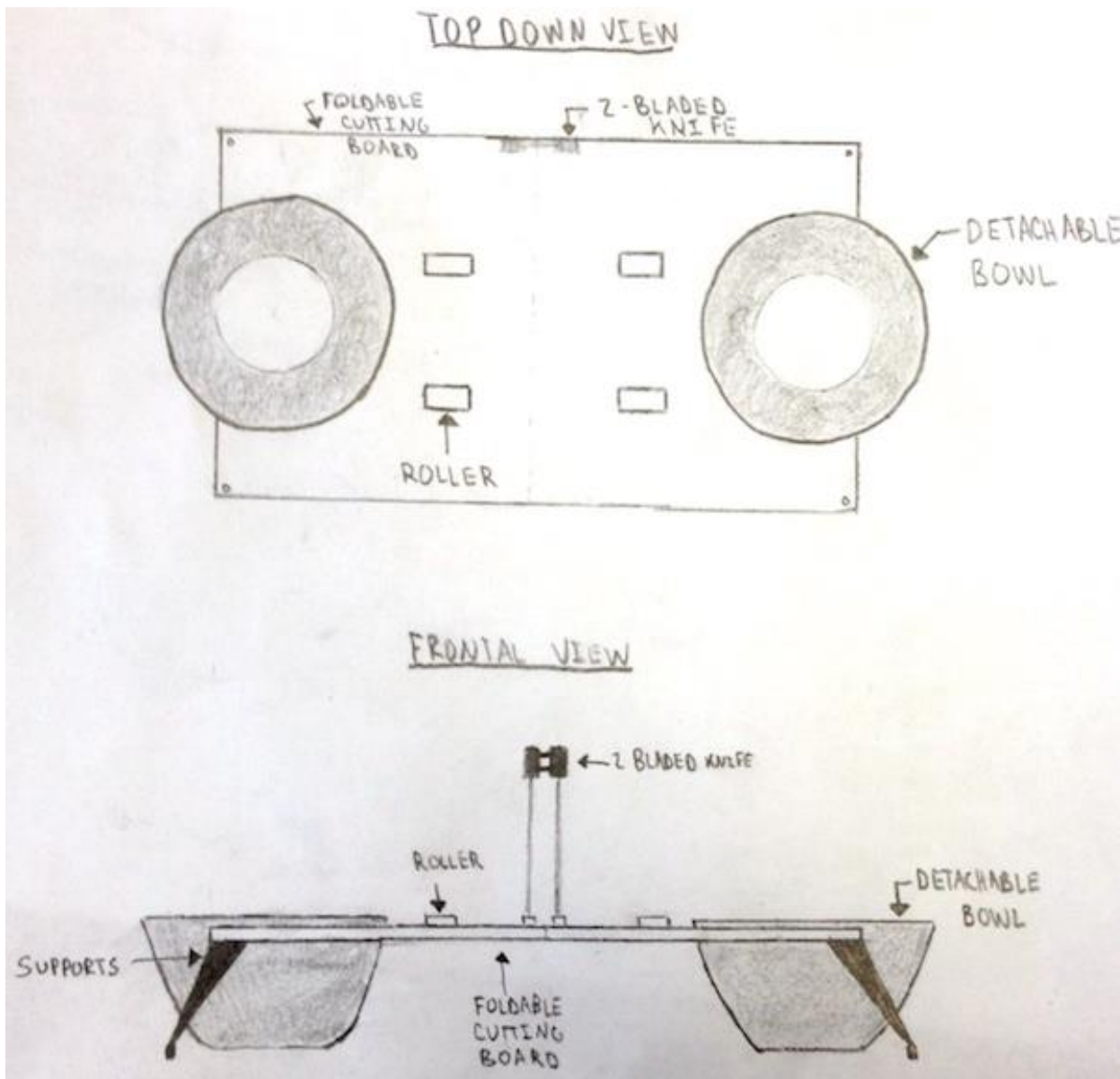


Figure 3.2.4-Concept 4-Foldable Watermelon Cutter

3.3 A concept selection process. This will have three parts:

3.3.1 Concept scoring (not screening)

Watermelon Washer and Cutter Concept 1		Metric										Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
		Length	Volume	Time	# of Sharp Edges	Cost	Size of First Disc	Weight	Strength of Device	Durability	# of Assembly Parts			
Need#	Need	1	2	3	4	5	6	7	8	9	10			
1	Cuts 1" Slice						1					1	0.1041667	0.104167
2	Affordable					0.8			0.067	0.067	0.066	0.649917	0.1041667	0.0677
3	Quick use			0.6					0.1		0.3	0.549123	0.1041667	0.0572
4	Easily Stored	0.05	0.5		0.05			0.25			0.15	0.351786	0.0625	0.021987
5	Easily Cleaned		0.3	0.4	0.1			0.1			0.1	0.437907	0.0625	0.027369
6	Adjustable Use	0.34	0.33						0.33			0.11	0.1041667	0.011458
7	Minimizes Mess			1								0.526316	0.1041667	0.054825
8	Facilitates Washing			1								0.526316	0.1041667	0.054825
9	Assist Melon Storage			0.8				0.2				0.592481	0.0833333	0.049373
10	Indoor Outdoor	0.25	0.25		0.25			0.25				0.401786	0.0625	0.025112
11	Safely and Easily Operated	0.1	0.1	0.1	0.2			0.1	0.2	0.1	0.1	0.496679	0.1041667	0.051737
Units		in	in^3	minutes	integer	Dollars	in	lbs	lbf	Integer	Integer	Total Happiness		0.525752
Best Value		13	390	1	1	20	1	3	100	100	1			
Worst Value		24	2400	20	5	50	3	10	25	20	10			
Actual Value		24	2400	10	2	30	1	4	50	80	4			
Normalized Metric Happiness		0	0	0.5263158	0.75	0.6666667	1	0.8571429	0.3333333	0.75	0.6666667			

Figure 3.3.1.1- Concept 1 Score

Watermelon Washer and Cutter Concept 2		Metric										Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
		Length	Volume	Time	# of Sharp Edges	Cost	Size of First Disc	Weight	Strength of Device	Durability	# of Assembly Parts			
Need#	Need	1	2	3	4	5	6	7	8	9	10			
1	Cuts 1" Slice						1					1	0.1041667	0.104167
2	Affordable					0.8			0.067	0.067	0.066	0.679917	0.1041667	0.070825
3	Quick use			0.6					0.1		0.3	0.549123	0.1041667	0.0572
4	Easily Stored	0.05	0.5		0.05			0.25			0.15	0.816276	0.0625	0.051017
5	Easily Cleaned		0.3	0.4	0.1			0.1			0.1	0.701879	0.0625	0.043867
6	Adjustable Use	0.34	0.33						0.33			0.957313	0.1041667	0.09972
7	Minimizes Mess			1								0.526316	0.1041667	0.054825
8	Facilitates Washing			1								0.526316	0.1041667	0.054825
9	Assist Melon Storage			0.8				0.2				0.592481	0.0833333	0.049373
10	Indoor Outdoor	0.25	0.25		0.25			0.25				0.931947	0.0625	0.058247
11	Safely and Easily Operated	0.1	0.1	0.1	0.2			0.1	0.2	0.1	0.1	0.844855	0.1041667	0.088006
Units		in	in^3	minutes	integer	Dollars	in	lbs	lbf	Integer	Integer	Total Happiness		0.732071
Best Value		13	390	1	1	20	1	3	100	100	1			
Worst Value		24	2400	20	5	50	3	10	25	20	10			
Actual Value		13	650	10	1	30	1	4	100	80	6			
Normalized Metric Happiness		1	0.8706468	0.5263158	1	0.6666667	1	0.8571429	1	0.75	0.4444444			

Figure 3.3.1.2- Concept 2 Score

Watermelon Washer and Cutter Concept 3		Metric										Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
		Length	Volume	Time	# of Sharp Edges	Cost	Size of First Disc	Weight	Strength of Device	Durability	# of Assembly Parts			
Need#	Need	1	2	3	4	5	6	7	8	9	10			
1	Cuts 1" Slice						1					1	0.1041667	0.104167
2	Affordable					0.8			0.067	0.067	0.066	0.3359	0.1041667	0.03499
3	Quick use			0.6					0.1		0.3	0.211228	0.1041667	0.022003
4	Easily Stored	0.05	0.5		0.05			0.25			0.15	0.523881	0.0625	0.032743
5	Easily Cleaned		0.3	0.4	0.1			0.1			0.1	0.439592	0.0625	0.027474
6	Adjustable Use	0.34	0.33						0.33			0.323761	0.1041667	0.033725
7	Minimizes Mess			1								0.263158	0.1041667	0.027412
8	Facilitates Washing			1								0.263158	0.1041667	0.027412
9	Assist Melon Storage			0.8				0.2				0.410526	0.0833333	0.034211
10	Indoor Outdoor	0.25	0.25		0.25			0.25				0.61194	0.0625	0.038246
11	Safely and Easily Operated	0.1	0.1	0.1	0.2			0.1	0.2	0.1	0.1	0.527759	0.1041667	0.054975
Units		in	in^3	minutes	integer	Dollars	in	lbs	lbf	Integer	Integer	Total Happiness		
Best Value		13	390	1	1	20	1	3	100	100	1			
Worst Value		24	2400	20	5	50	3	10	25	20	10			
Actual Value		24	1500	15	1	40	1	3	65	60	10			
Normalized Metric Happiness		0	0.4477612	0.2631579	1	0.3333333	1	1	0.5333333	0.5	0	0.437358		

Figure 3.3.1.3- Concept 3 Score

Watermelon Washer and Cutter Concept 4		Metric										Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
		Length	Volume	Time	# of Sharp Edges	Cost	Size of First Disc	Weight	Strength of Device	Durability	# of Assembly Parts			
Need#	Need	1	2	3	4	5	6	7	8	9	10			
1	Cuts 1" Slice						1					1	0.1041667	0.104167
2	Affordable					0.8			0.067	0.067	0.066	0.664917	0.1041667	0.069262
3	Quick use			0.6					0.1		0.3	0.549123	0.1041667	0.0572
4	Easily Stored	0.05	0.5		0.05			0.25			0.15	0.904664	0.0625	0.056542
5	Easily Cleaned		0.3	0.4	0.1			0.1			0.1	0.73138	0.0625	0.045711
6	Adjustable Use	0.34	0.33						0.33			0.879328	0.1041667	0.091597
7	Minimizes Mess			1								0.526316	0.1041667	0.054825
8	Facilitates Washing			1								0.526316	0.1041667	0.054825
9	Assist Melon Storage			0.8				0.2				0.621053	0.0833333	0.051754
10	Indoor Outdoor	0.25	0.25		0.25			0.25				0.929415	0.0625	0.058088
11	Safely and Easily Operated	0.1	0.1	0.1	0.2			0.1	0.2	0.1	0.1	0.763287	0.1041667	0.079509
Units		in	in^3	minutes	integer	Dollars	in	lbs	lbf	Integer	Integer	Total Happiness		
Best Value		13	390	1	1	20	1	3	100	100	1			
Worst Value		24	2400	20	5	50	3	10	25	20	10			
Actual Value		13	455	10	2	30	1	3	75	80	5			
Normalized Metric Happiness		1	0.9676617	0.5263158	0.75	0.6666667	1	1	0.6666667	0.75	0.5555556	0.72348		

Figure 3.3.1.4- Concept 4 Score

3.3.2 Preliminary analysis of each concept's physical feasibility

Concept #1: Watermelon Barrel

The watermelon barrel (Concept #1) is a design that uses small metal rods welded together in a barrel-like shape. Attached to the lower portion of this barrel are rollers that help to rotate the watermelon. The lower portion of the bowl is then rested on a rectangular base that is split into three sections, two for wrapping the watermelon halves and one that contains a bath of a water and surfactant mixture that cleans the surface of the watermelon in unison with two brushes. Concept #1 performs well in regards to several of our given metrics, however its' score in other key areas makes it less ideal than some of the other concepts. Concept #1 scores well in regards to weight, cost, and the number of assembly parts. By utilizing a cage-like structure for the main body, concept 1 requires less material which ultimately makes it lighter, cheaper and easy to clean. The design of Concept #1 also performs well against the user needs of not having too many sharp edges and cutting a 1" first slice (although these blades weren't designed to be adjustable). However, some difficulty may arise in assembling and welding the structure together. Some of the main issues with this design is the overall size and strength of the device. The size of this design will cause issues for storage which is something that was high on our user needs list. Also, since this device is made from a cage-like structure held together by welding, it may not be strong enough to support the watermelon, especially when the blades put pressure on the watermelon in order to cut it. This design allows for easy handling of the watermelon since it does not require lifting when trying to clean it. The design of Concept #1 is similar to that of Concept #2 and #4 in regards to the fact that they all utilize a similar cutting motion with slight variations. This design is also similar to Concept #4, because they both utilize rollers on the base of their structures to turn the watermelon for cleaning. However in this design the rollers are permanently placed whereas the rollers in Concept #4 are removable. Overall, this concept is not an ideal choice mainly due to the reason that it is large and not great for storage purposes.

Concept #2: Sliding Cutting Board

This concept scored the highest in our scoring process. The sliding cutting board allows for a quick assembly of the entire device while also providing a compact system to store. It easily adjusts to different sized melons and the knife is able to slide freely on a rod and lock into place so cutting the first disc of melon can be accomplished rather easily. The high number of parts required for the assembly, however, contributes to a slightly longer overall time when disassembly and cleaning are factored in. Since the board is a relatively compact piece, the board can also support a rather large load, which allows for bigger melons to be cut with this device compared to the others we considered. This concept and two others shared the same cutting mechanism, but this concept differed in that it had "pinching" rotating end pieces that can be removed for ease of storing the cut halves. Some physical limitations present themselves with this concept, however. We estimate that the removable end pieces that have rotating sections within them and the free sliding knife sub-assembly would be difficult to manufacture.

Concept #3: Suspended Watermelon

Concept #3 is designed for washing and cutting the watermelon; however, it does not cover wrapping the watermelon in plastic wrap. This concept can be used both inside and outside. The brush on the top can scrub most of the watermelon for cleaning off dirt or any bacteria left on it, but it cannot clean the two ends of it. The handle on the left side is threaded so it can adjust to different size watermelon and also tighten the watermelon where it can be held up. The right handle is used to rotate the watermelon as it is being washed and to spin the watermelon as it is being cut. The lever arm connected to the right handle is longer than the lever arm connected to the left handle because a greater moment must be applied to rotate the watermelon when cutting. The concept can be disassembled into multiple parts so it can be put away for storage. Ideally, the supports would be made from a corrosion resistant material like stainless steel. Some bearings will be needed to rotate the left watermelon cup and on the right part of the stand that allows the right handle to rotate around. The cost compared to the other designs is higher because there are more parts required to make this design to work. Also since there are many parts, the time would be an issue since it would take a lot about 5 minutes to assemble it and then another 5 minutes to disassemble it. The positive for this concept that it can be easy to store except for the stand and the watermelon catcher. The length of the concept is longer than the width of a double sink which can take up a lot of room. Another issue could be the durability because there will be huge moments on the bars as the watermelon is put in place.

Concept #4: Foldable Watermelon Cutter

This concept utilizes a cutting board, 2 bowls and a double bladed knife. The 2 bowls can be removed to store the watermelon and also be cleaned with ease. The double bladed knife can be removed and cleaned with ease as well. The cutting board will be able to fold up to half of its length and be stored with ease. The cutting board contains removable rollers that allow the watermelon to spin in order to clean and dry. These are similar to Concept #1, but are removable and in a cutting board. The double blade is also similar to Concept #1, but it takes the shape of a normal knife, not a curved blade. The removable bowls serve the same purpose as the removable end pieces in Concept #2, but are different designs. The cutting board portion of this concept is also similar to Concept #2, but instead of sliding, it folds for storage. Concept #4 allows the design to be small in volume, which is good for storage and use. It also cuts a disc in one motion instead of two. The time it takes could be around 10 minutes, but this is not certain. The number of assembly parts make it easy to store, but could make the overall time longer. This design would incorporate fruit sterilizing spray and a scrub brush to clean the watermelon. This concept scored 2nd overall in the happy equations.

3.3.3 Final summary

Concept Winner: Concept #4

Concept #4, even though it did not come in first in our scoring process, will be the easiest to manufacture and assemble. The removable bowls will make storing the halved watermelon much easier than any of the other designs. The dual blade design will allow quick, equally spaced cuts, and simultaneously will only require one cutting motion. This design also consists of relatively few assembly parts, so the time required to assemble and cut the watermelon is less than our other concepts. This concept will also be able to be stored the easiest, since the bowls are removable and it folds in half. The bowls could also be used to store other food items or even act as a strainer. We also plan on using a surfactant spray bottle and either a brush or pad to clean the melon and leave very little mess. Although this design only scored 1% lower than the highest scoring concept, our physical analysis justifies going ahead with embodiment and fabrication.

3.4 Proposed performance measures for the design

1. Can cut and support a 25 lb watermelon.
2. Broken down and stored in standard drawers.
3. Equipped with storage bowls that fit in refrigerator
4. Can clean, cut and store, in under 10 minutes.
5. Requires less than 2 minutes of clean up after cutting.

3.5 Design constraints

3.5.1 Functional

The most important functional design constraint we considered for this project is the relationship between the cutting assembly and the board assembly. Careful geometric considerations had to be made to ensure that the knives made contact with the board all along their edge after a cutting motion. The knives then had to be kept at an upright position out of the way of the rollers and caps while the melon or other produce can be manipulated.

Another functional constraint that was important for this design is the roller geometry. The rollers had to be placed at specific distances with respect to each other to ensure that many different sizes of produce can fit in this system. If the rollers were too far apart, only very large melons could fit since smaller ones would fit between the rollers. If the rollers were too close to each other, then it is likely the melon would slip off of them and they would not be useful.

3.5.2 Safety

We had to include considerable safety measures for this design. As our prototype progressed it became apparent that we needed some way to cover the knives when they were not in use and also to restrain the watermelon from moving during the cutting action. We included removable

knife covers that keep the knives covered until they are needed. We also included removable “safety stoppers” that keep the watermelon from sliding off the rollers during the cut.

3.5.3 Quality

Part of the initial prototype presentation stated that the design needed to be “robust” and well built. We concentrated on this aspect during the manufacturing process. We used industrial strength materials for parts of our design that would be load bearing. We also made careful measurements during assembly to ensure that everything would fit together appropriately and would allow the cutting mechanism to work properly.

3.5.4 Manufacturing

We knew that once we finalized the design, we would be the ones in the machine shop making our prototype. Therefore, we made conscious decisions while designing the prototype to make the parts simple to manufacture. If someone in the group proposed a change in the design the first question we asked ourselves was “alright, how can we make this part?” If we decided the part would not be easily manufactured, we either changed it or stared over with the piece. This process led us to our final design, which we were successfully able to completely manufacture to our specifications.

3.5.5 Timing

Easily our biggest timing constraint was having this project finished this semester. Throughout the semester there were aspects of this project that needed to be completed and submitted for course credit. This helped us complete important tasks on time and keep the project moving forward at a steady pace.

3.5.6 Economic

Since the goal of this project was to hopefully create a device that could one day be a household item, the final assembly could not be too expensive. We also had a \$300 budget for this project. Therefore our design could not contain any parts that were overly expensive. We decided to buy some rather high-end knives since we knew that these pieces would be the most important part of our design. If the knives could not cut the watermelon, our design would be a failure.

3.5.7 Ergonomic

The ergonomic considerations we made during this project relate mostly to comfort of the user during the cutting stroke. We had to ensure that the prototype fit comfortably in front of the user so that the user did not have to make any awkward feeling motions during the cut. We also wanted to make sure that the entire system did not weigh too much so that it can be easily moved from its storage location to where it is going to be used.

3.5.8 Ecological

The biggest ecological design constraint we considered dealt with the surfactant we decided to use. Since we did not want to use some external source of running water, i.e. a spray nozzle on a sink or any other form, we decided that a surfactant would be the best solution to minimize mess and also reduce the amount of water wasted. The surfactant we chose is applied via a sponge or

clean towel with no running water needed. In this way, we can help minimize the amount of water used and wasted.

3.5.9 Aesthetic

Since this prototype had to be completed within the budget, very minor aesthetic constraints were considered. Eventually, if the product were to be marketed commercially, certain changes would have to be made, namely color matching certain parts, making everything “flow” better. As in make the corners more rounded and the interface between parts more seamless.

3.5.10 Life cycle

The life cycle of this system had to be considered carefully. We imagined this as an eventually commercially available product. With that in mind we wanted to design a product that could last the consumer a considerable amount of time without breaking or wearing out. One wearing aspect we encountered early was the dulling of the knife blades. Since this sort of wear occurs on all knife blades we did not overly concern ourselves with this, however. We predict that the rest of the assembly should be able to last for a while since they are made from steel, aluminum, and strong commercial plastic.

3.5.11 Legal

The only major legal design constraint we considered was to not infringe upon any existing patent or relative device currently in existence.

4 Embodiment and fabrication plan

4.1 Embodiment drawing

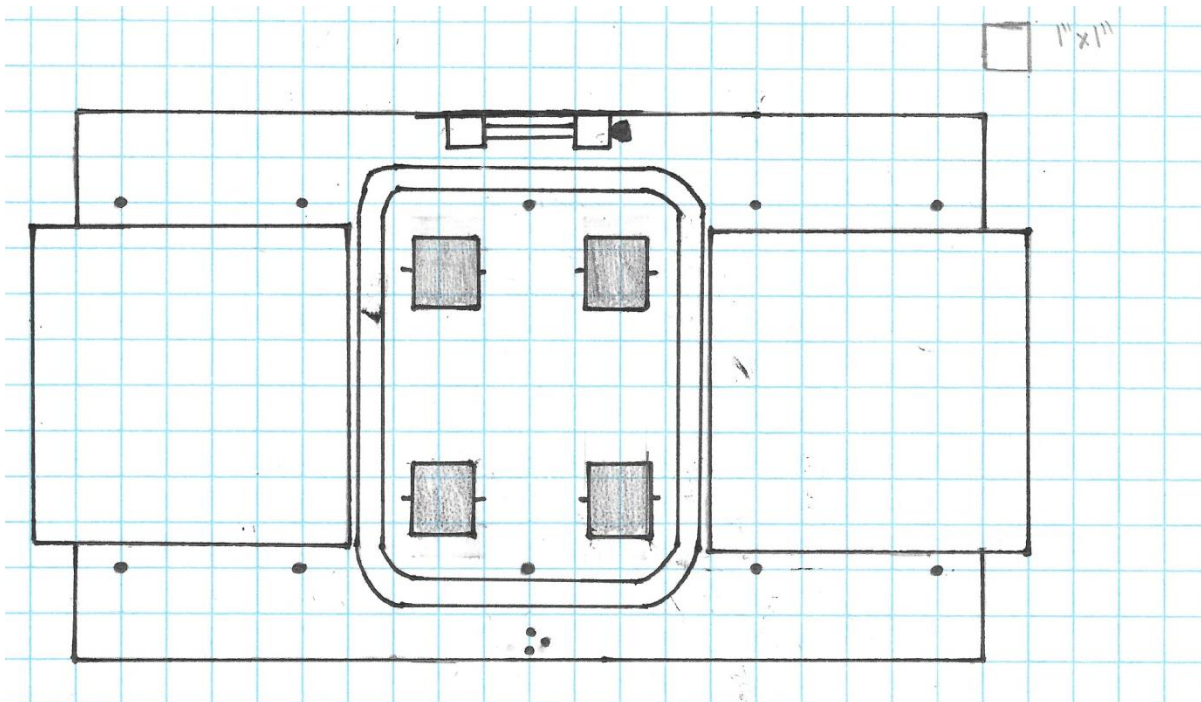


Figure 4.1.1- Top Down View of Chosen Concept

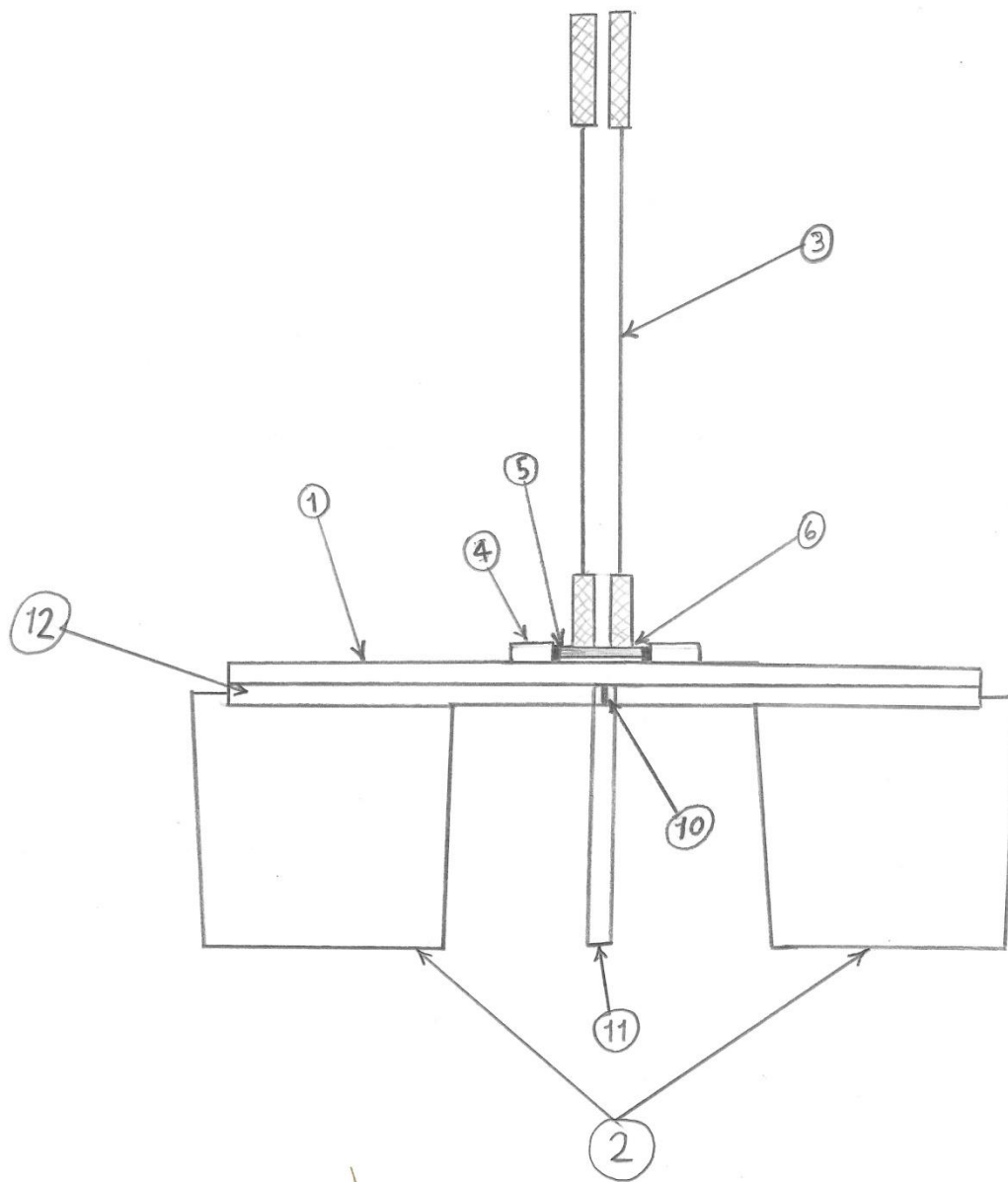


Figure 4.1.2- Front View of Chosen Concept

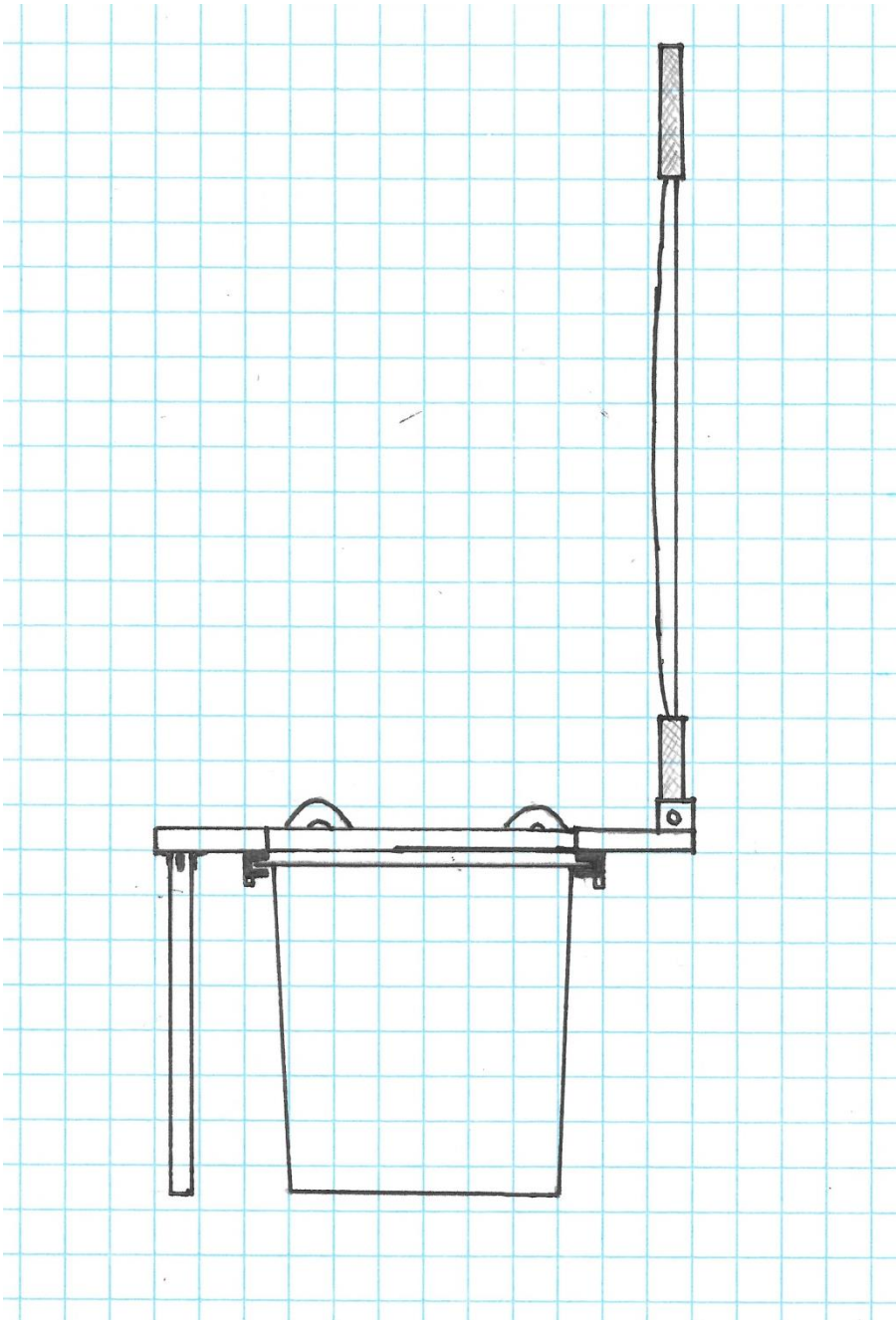


Figure 4.1.3- Side View of Chosen Concept

4.2 Parts List

Parts List

1. Cutting Board
2. Stainless Steel Square Bowls (2)
3. Cutlery Knife (2)
4. Rollers (4)
5. Blocks (2)
6. Knife Shaft
7. Bolts (10)

- 8. Nuts (14)
- 9. Leg Bolts (4)
- 10. L-Brackets (3)
- 11. Support Leg
- 12. C-Channels

Table 4.2.1

Materials List						
Part Number	Item Description	Item Purpose	Source	Quantity	Catalog Number	Cost
1	20"x15"x3/4" Plastic Cutting Board	Sized and Shaped into Custom Cutting Board	Webstaurant Store	1	20315201	16.49
2	180x180x170 Stainless Steel Square Bowl	Stainless Steel Bowls	Webstaurant Store	2	Team Supplied	
3	14" Mercer Edge Slicer Knife	Knives	Webstaurant Store	2	470M13914	43.22
4	1.5" Aluminum Rod, 1' long	Custom Rollers	McMaster-Carr	1	8974K18	16.54
5	1"x1"x6" Aluminum Stock	Aluminum Blocks	McMaster-Carr	1	9008K14	4.4
6	1/2" Diam Steel Shaft 1' Length	Knife Shaft	McMaster-Carr	1	8920K155	3.32
7	Stainless Steel Flat-Head Socket Cap Screws	C-Channel Bolts	McMaster-Carr	1	90585A996	4.13
8	Hex Nuts	Nuts	McMaster-Carr	1	90480A195	1.83
9	Stainless Steel Flat-Head Socket Cap Screws	Aluminum Block Screws	McMaster-Carr	1	90585A994	3.86
10	Zinc Plated Angle Brackets	L-Brackets	McMaster-Carr	3	1556A26	1.89
11	Multipurpose 6061 AL 1" diameter 1' length	Support Leg	McMaster-Carr	1	8974K13	9.10
12	1/2"x1"x6' AL square stock	C-Channels	McMaster-Carr	1	8975K11	23.37
					Total:	128.15

4.3 Draft detail drawings for each manufactured part

This section contains the preliminary CAD drawings we generated for the manufactured parts of our prototype. The final CAD drawings with modifications made during the manufacturing process are found in Appendix C.

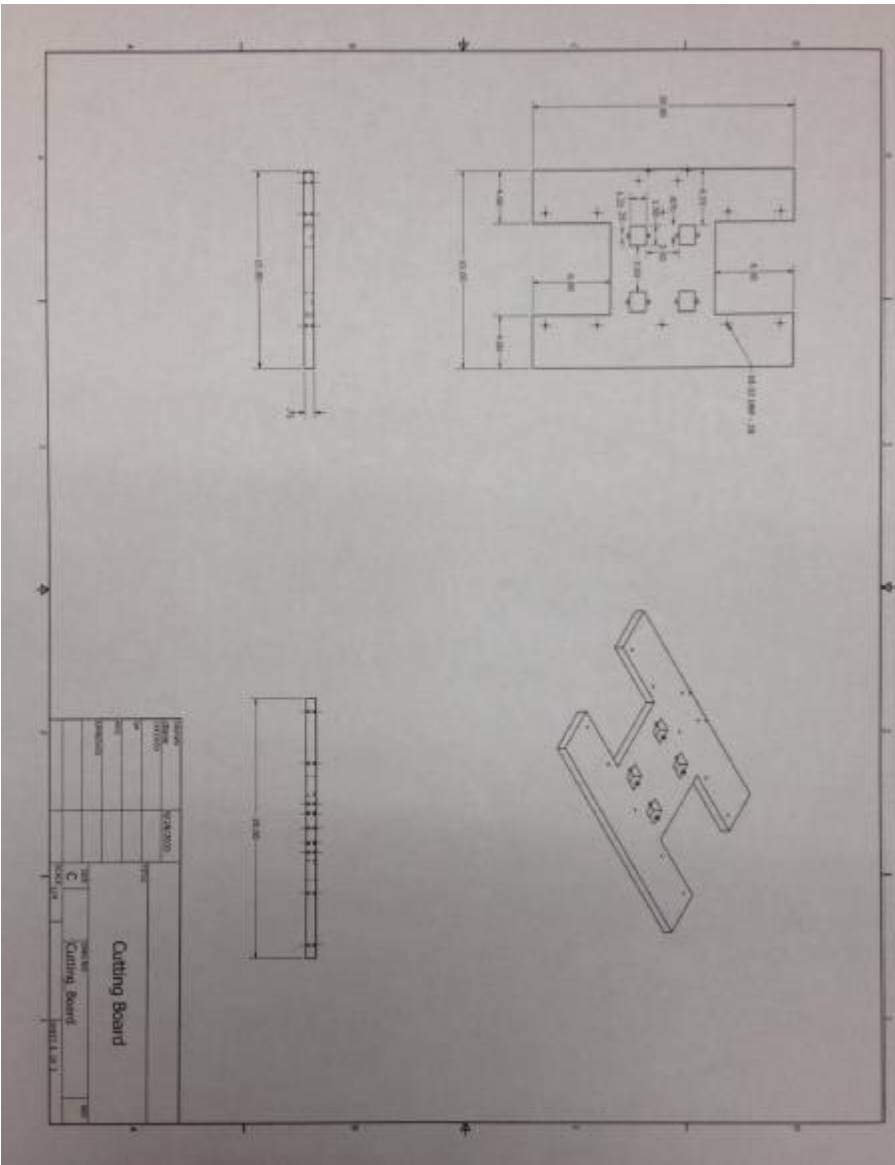


Figure 4.3.1- Cutting Board

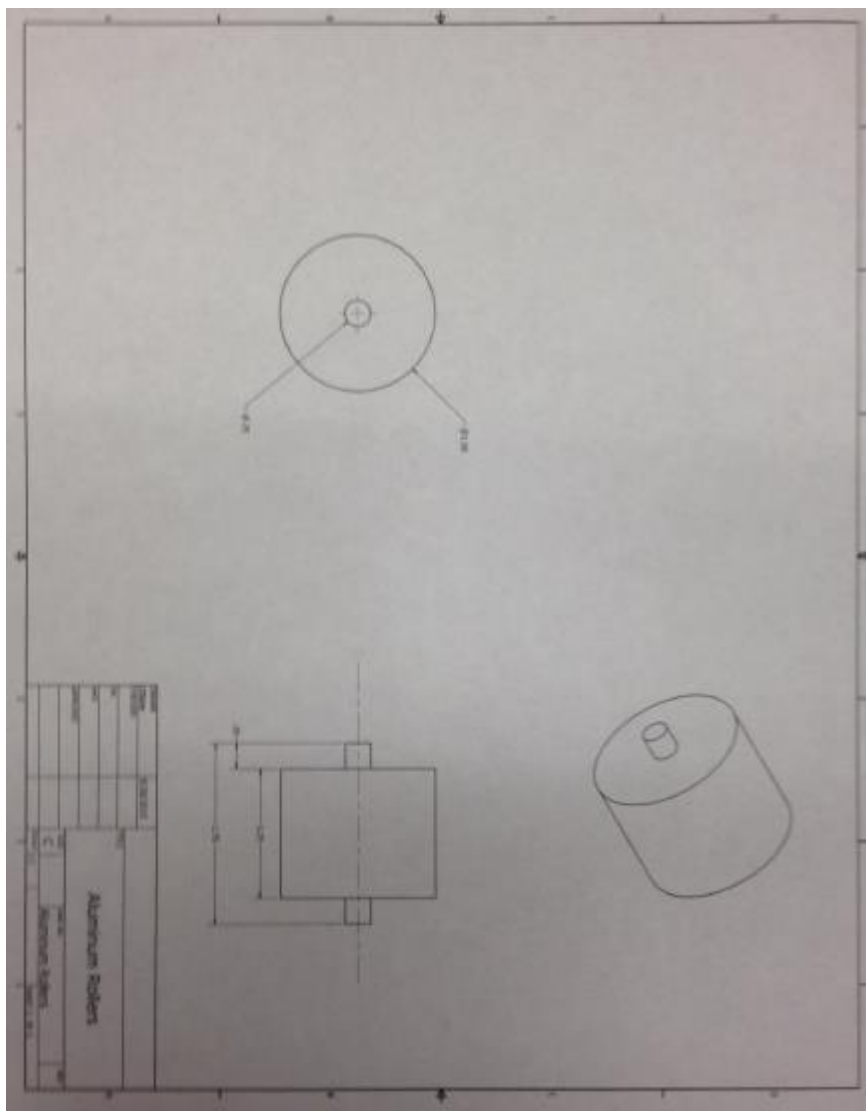


Figure 4.3.2- Roller

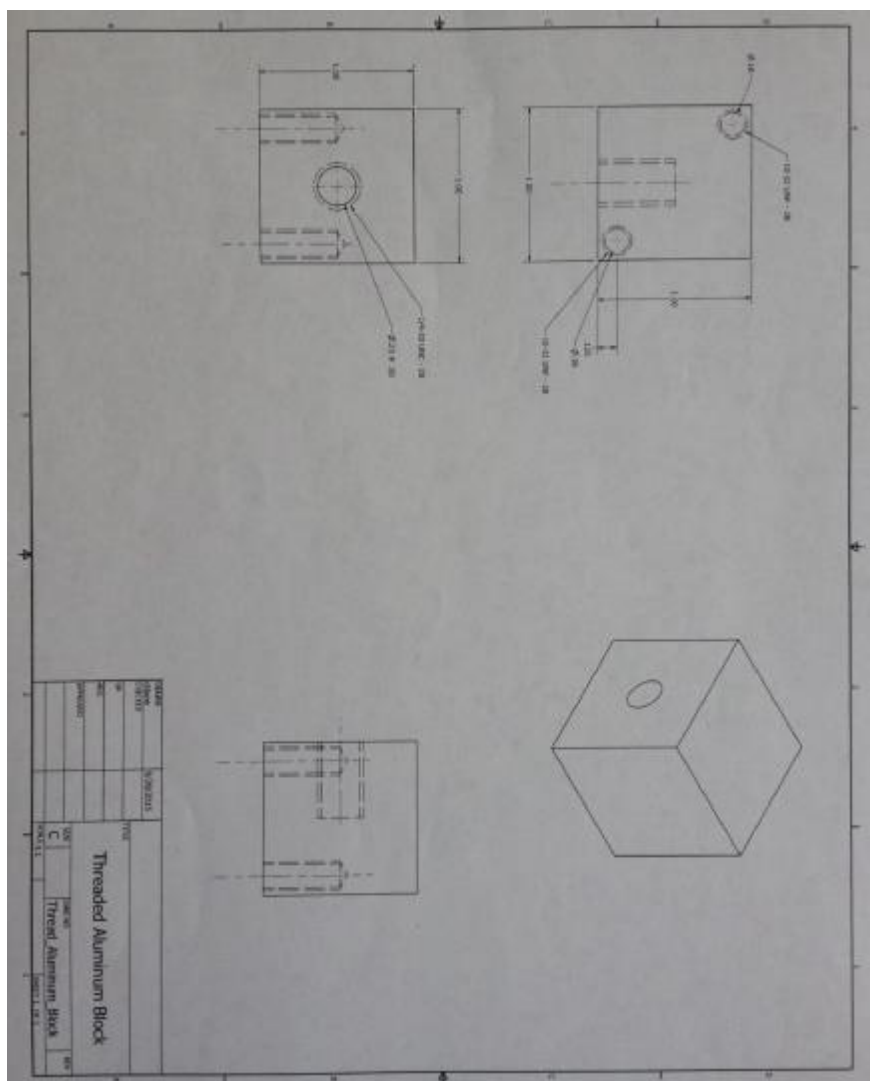


Figure 4.3.3- Pillow Block Type 1

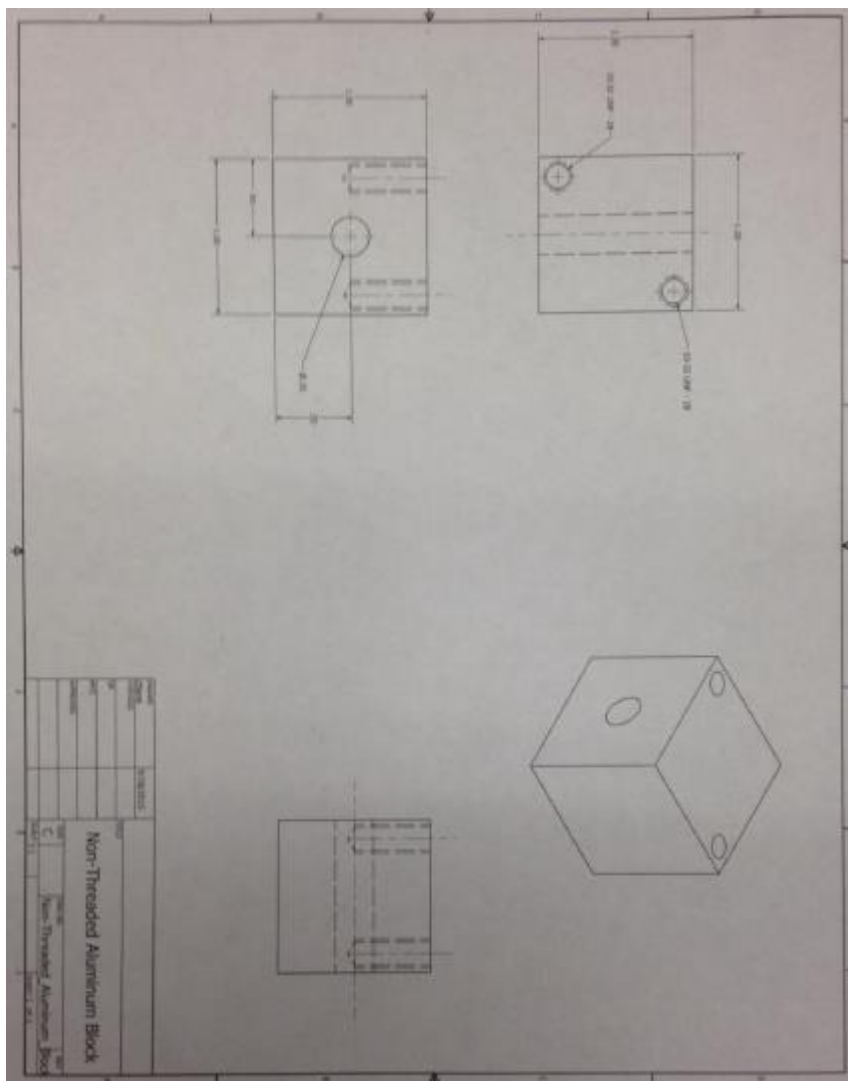


Figure 4.3.4- Pillow Block Type 2

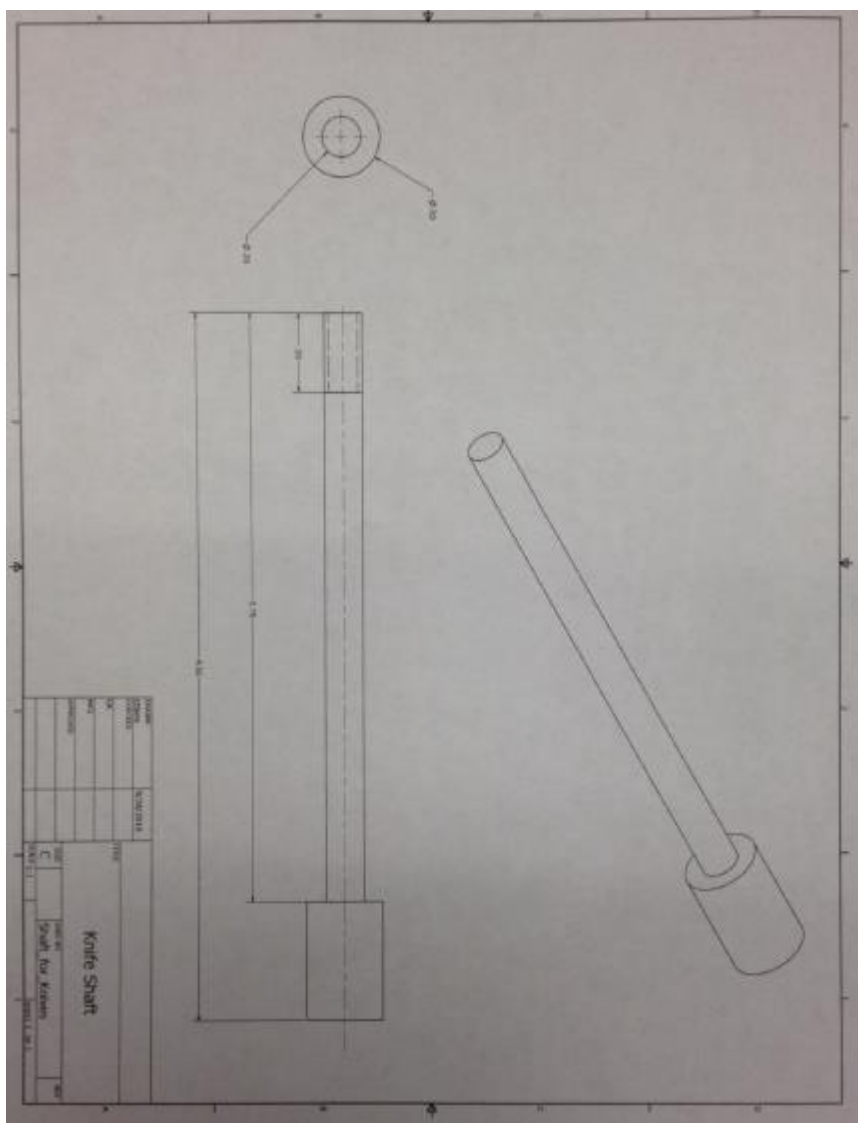


Figure 4.3.5- Knife Shaft

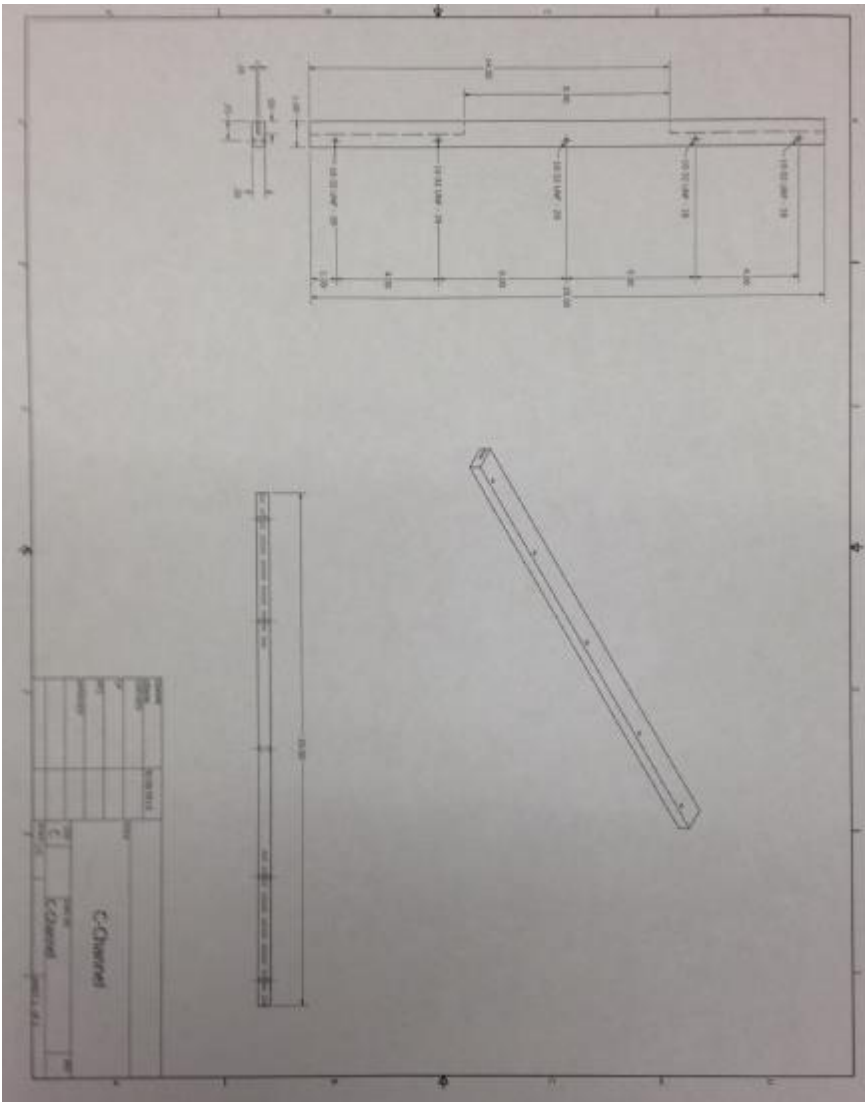


Figure 4.3.6- C-Channel

4.4 Description of the design rationale for the choice/size/shape of each part

1. Cutting Board

The cutting board was chosen based on several design considerations we wanted to implement. First, the board needed to fit within a standard drawer in a kitchen for ease of storage. Since the standard drawer is 20 inches deep, 14 inches wide and 3.5 inches tall, the board size we chose accommodates this. Second, the board needed to be thick enough to allow the four rollers to be recessed into the board so the watermelon can spin freely during the washing process. Since the load bearing portion of the rollers are $\frac{1}{4}$ " thick and we desire to press fit open bushings into the board, we decided that the $\frac{3}{4}$ " thick board would best suit our needs. The board purchased is 15" wide, and therefore needs to be cut down to the desired 12" width. The large slots where the bowls are inserted will need to be removed by cutting and the channel for catching the liquid will be routed into the board.

2. Stainless Steel Square Bowls

The bowls listed here were chosen to accommodate a half of a large watermelon. Since the bowls are about 7 inches deep and nearly 50 square inches, the largest watermelon sample we considered will

protrude only slightly and can easily be plastic wrapped for storage. The bowls will also be load bearing since the entire force of the weight of the watermelon plus the downward cutting force will be applied; hence our choice of stainless steel rather than plastic is appropriate.

3. Cutlery Knife

The knives we chose here were decided upon solely from geometric considerations. In order to allow the knife to completely pass through a 10 inch diameter watermelon while being fixed at one end (on our pivot rod), the knife had to be, at minimum, 12 inches long. Therefore, to be safe, we decided on a 14 inch blade knife. This knife will also not extend too far past the edge of the cutting board in its lowest position.

4. Rollers

The rollers in this design are custom fabricated. We decided to use a 1.5 inch diameter roller so that when the watermelon is resting on them during the washing process, it can easily rotate on all four rollers. The rollers will also hold the melon in place during the cutting process. Since the knife will apply a downward and forward force on the melon, the rollers will act upward and backward on the melon, effectively holding it in place. The rollers are placed on the board, with respect to each other, to ideally accommodate a wide range of melon sizes and to allow the knife blades to pass unimpeded through the melon.

5. Aluminum Blocks

The aluminum blocks that are on top of the cutting board holding the knife are custom fabricated. One block is tapped to accommodate the threaded portion of the knife rod and the other block has a hole drilled completely through and bushings press fit into it to allow the knife rod to rotate effortlessly within it. The aluminum blocks will be attached to the cutting board via 2 screws each. Aluminum was chosen as the material as we feel it will aesthetically tie in to the rest of the apparatus.

6. Knife Shaft

The knife shaft is $\frac{1}{4}$ " steel rod with an oversized handle that will be used to turn the shaft into the aluminum block. Since the distance between the aluminum blocks is small and the upward reactive force from the knives is small the bending in the knife shaft is such that a $\frac{1}{4}$ " low-carbon steel shaft is an apt choice.

7-9. Bolts and Nuts

The $\frac{3}{16}$ " bolts used in this apparatus attach the C-Channels to the cutting board, attach the aluminum blocks to the cutting board and attach the support leg to the cutting board. The forces encountered by this apparatus are small enough to allow the bolts chosen here to easily support the load.

10. L-Brackets

Two of the L-Brackets here are used to allow the support leg to swivel. This allows the leg to fold up to the board which allows the board to be easily stored. The third L-Bracket is placed such that it restricts the motion of the support leg and stops in at a 90 degree angle relative to the board.

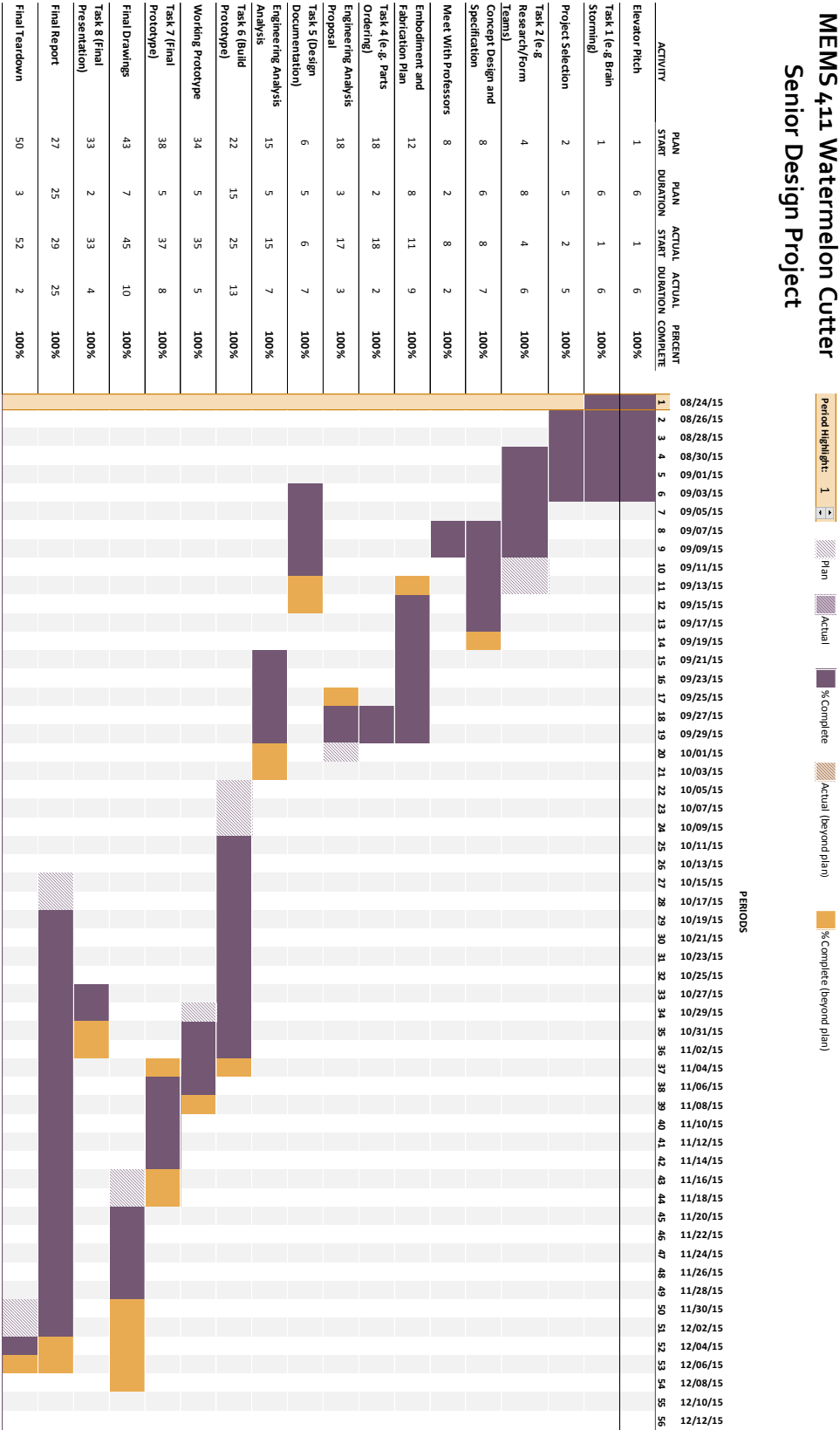
11. Support Leg

The support leg is used to prevent tipping of the system during the cutting process. It extends from the bottom of the board at an angle such that it extends outward past the edge of the cutting board. The analysis we did on the support leg showed that the force required to cause the leg to buckle far exceeds any expected force the system would encounter.

12. C-Channels

The C-Channels used here are custom fabricated. The channel in the beam is to allow the lip of the stainless steel bowl to slide into position relative to the cutting board. The channel stops to prevent forward movement of the bowls relative to the cutting board. The channels are designed to run the full length of the board. This provides substantial structural support to the cutting board. Our analysis showed that even when the load applied is much greater than anything physically expected, the channels deflect only minimally.

4.5 Gantt chart



5 Engineering analysis

5.1 Engineering analysis proposal

Prior Analysis

- Bending of C-Channel and Board
 - o Calculating deflection of c-channel and board
 - o By: John Jedlicka/Jack Walsh
- Buckling of Support Leg
 - o Calculating buckling force
 - o By: Jack Walsh/John Jedlicka
- Roller Geometry
 - o Calculating distance between rollers to support varied diameter watermelons
 - o By: John Jedlicka
- Knife Geometry
 - o Calculating length of knife based off of 10" diameter watermelon
 - o By: Eric Martel/Colin Lane/Jack Walsh/John Jedlicka

Post Analysis

- Surfactant testing
 - o Bacteria Culture Experiment using different cleaning supplies
 - o By: Eric Martel/Colin Lane
- Cutting Force
 - o Calculate Cutting Force through strain gauge methods or other methods
 - o By: Eric Martel/Colin Lane/Jack Walsh/John Jedlicka

5.2 Engineering analysis results

5.2.1 Motivation

The two most important prior analysis concepts we considered would be the bending of the support beams and the board and the roller geometry. If the beams and board were to undergo considerable deflection during the cutting process it is possible that a catastrophic failure could occur, either pulling a screw through the board or having the board actually break. The roller geometry is also an important aspect to consider. The rollers had to be placed at specific distances with respect to each other to ensure that many different sizes of produce can fit in this system. If the rollers were too far apart, only very large melons could fit since smaller ones would fit between the rollers. If the rollers were too close to each other, then it is likely the melon would slip off of them and they would not be useful.

5.2.2 Methodology

The engineering analysis we considered for this project did not include any particularly difficult computations or methods. Methods discussed in standard mechanical engineering classes like mechanics and deformable bodies were used to calculate the buckling and bending of the members.

5.2.3 Results

The figure below shows the calculations done for the engineering analysis.

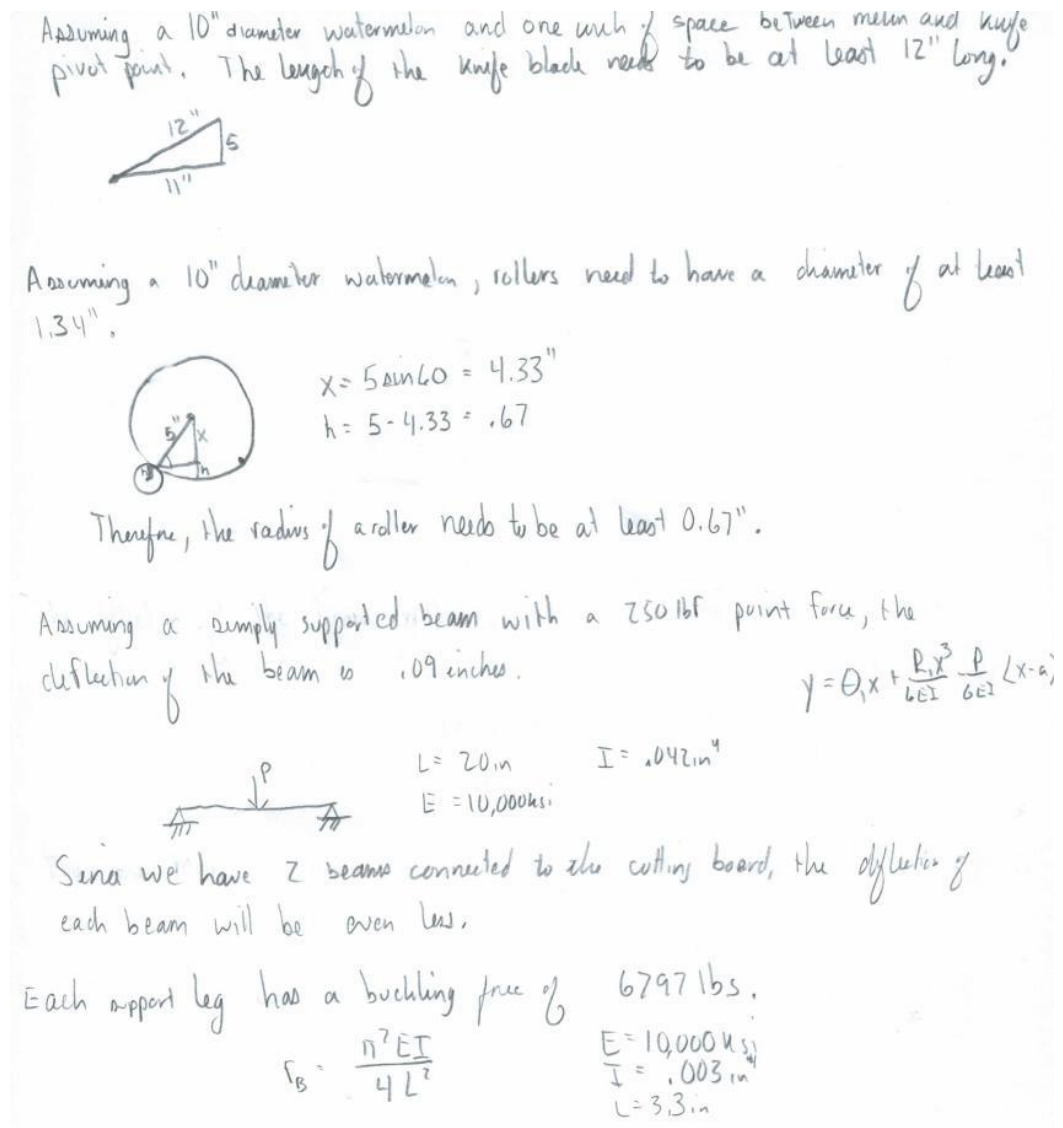


Figure 5.2.4.1-Engineering Analysis Results

Different components of the cutter were analyzed in order to construct a stable and long lasting product. The calculations are shown in the image below. Beams were added to the cutter in order to strengthen the board. The deflection of a support beam is less than .09 inches. This deflection was calculated by assuming a 250 lbf on a single beam. This force is much higher than any force a single beam will see. There are also two beams on the cutter. Together they will not deflect very much. There are also four legs that support the cutting board. The buckling force for each leg is over 6000 lbf. Therefore, the legs in combination will be able to support the weight and cutting force involved during a cut. The rollers were designed in order to support up to a ten-inch diameter watermelon. The diameter needs to be at least 1.34 inches. The knife blades need to be at least 12 inches long in order to cut a 10-

inch diameter watermelon. As for the surfactant, we found a recipe online which was tested to be 98% effective.

5.2.4 Significance

The significance of our results of the analysis mainly reinforces the assertions we made during the design process. We did have to make several changes, however. The bending of the board in the short direction was considerably more than we had anticipated, resulting in the addition of a support beam along the middle of the cutting board. We also changed from one support leg to four fully functioning legs. This decision did not result from the buckling analysis but from the tipping of the system. The shorter legs reduced the tipping substantially. The final roller assembly also changed. We went from four fixed rollers to four rollers that can change distances with respect to each other. This allows for many different sizes of produce. These changes can be seen in the figures below.

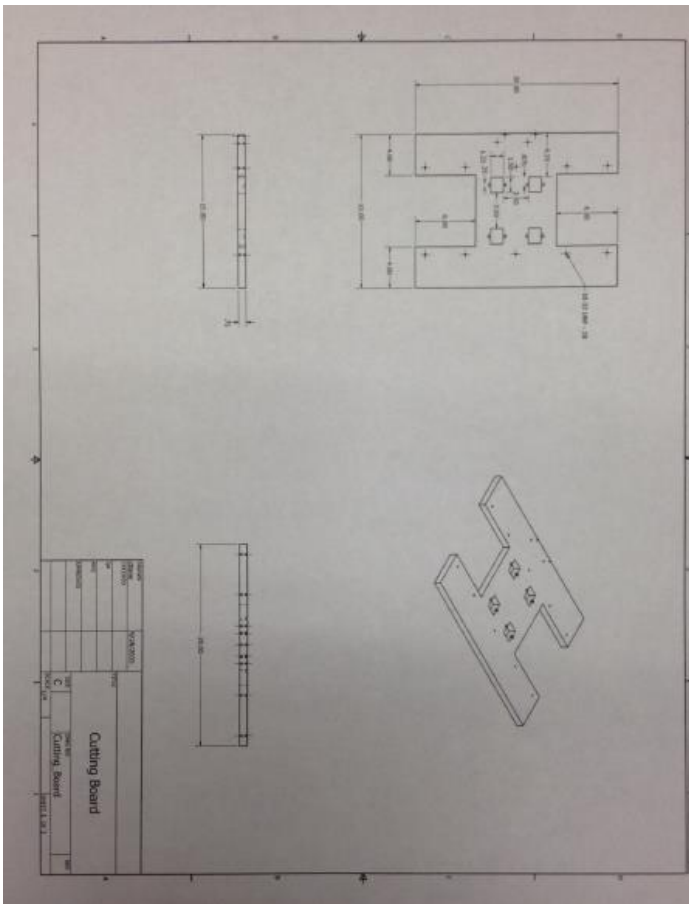


Figure 5.2.5.1- Initial Roller Configuration

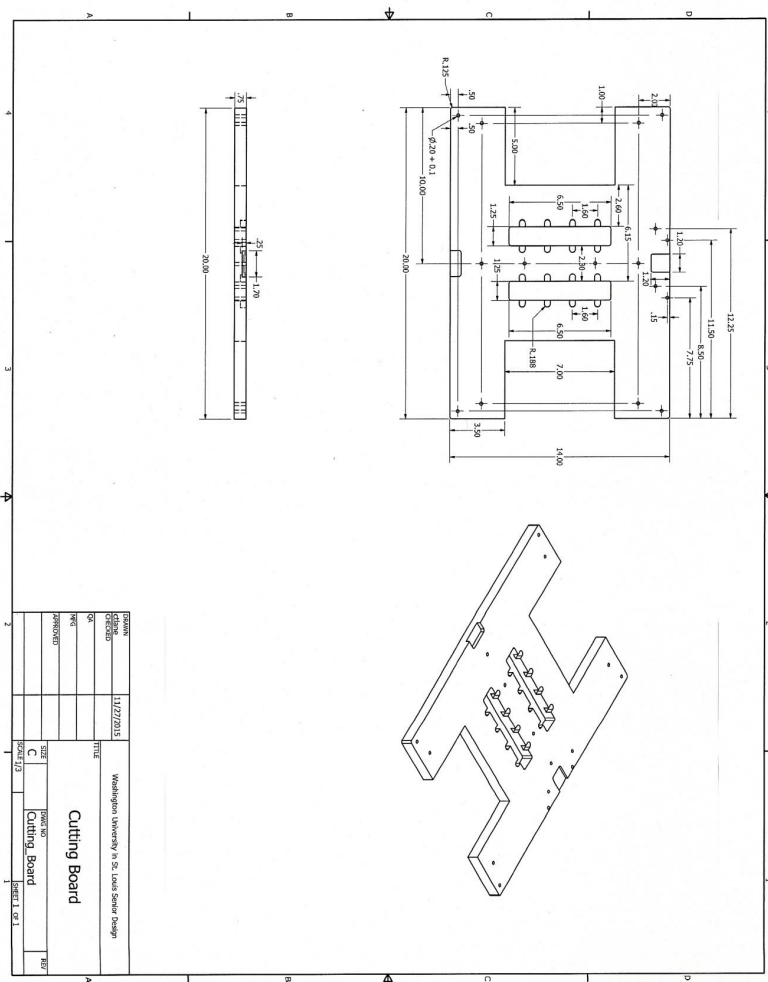


Figure 5.2.5.2- Final Roller Configuration

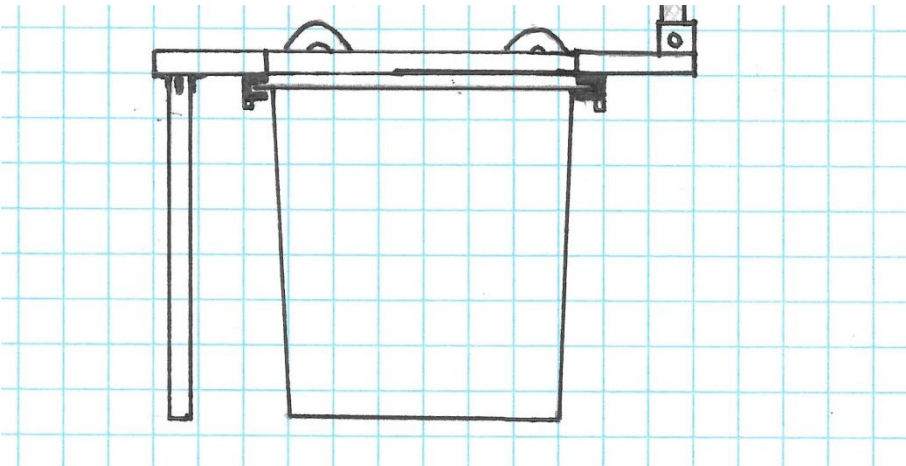


Figure 5.2.5.3- Initial Beam Configuration (no middle beam)

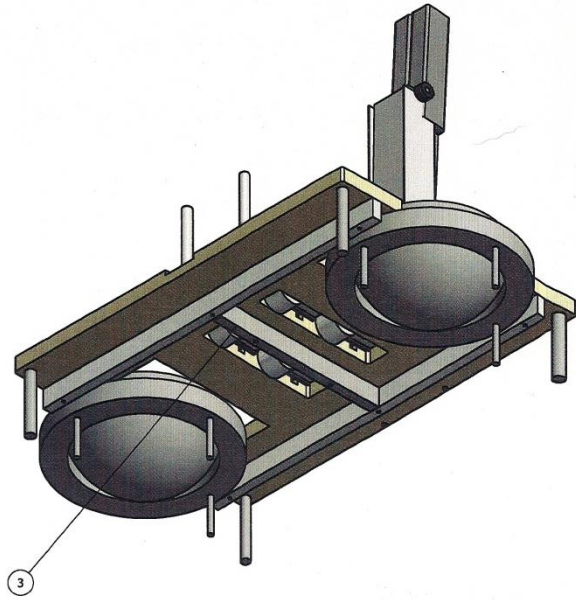


Figure 5.2.5.4- Final Beam Configuration

5.2.5 Summary of code and standards and their influence

The codes and standards we followed closest deal with material selection for food processing products. This being said, we decided to only use a food grade cutting board and knives for the sake of cost and time. To make all of the parts we used in the prototype food grade would have been much more costly and difficult to manufacture. The parts specifically that would need to be changed are the knife shafts, roller assemblies, support beams, legs etc. All parts in our prototype that were not made from plastic or stainless steel would need to be revised if this product were to be marketed to the public.

We also considered the standard size for kitchen drawers and sinks to constrain the size of the prototype. We wanted this system to be easy to clean and store after use.

The following URL's lead to the standards we used.

- http://standards.nsf.org/apps/group_public/download.php/3941/nsf51-97.pdf
- <http://homeguides.sfgate.com/building-kitchen-drawers-47342.html>

5.3 Risk Assessment

5.3.1 Risk Identification, Analysis, and Prioritization

Risk can be analyzed in terms of cost, schedule, and technical performance. Once the risk is analyzed, they are ranked in order of most importance to least importance. In doing so, one can see where the most risk lies and can begin to find ways to mitigate that risk or have a plan to reduce that risk. The

highest risk found during the design and construction of the watermelon cutter is the knives. The knives used are very sharp and are a very high safety concern. Due to the nature of our design, the knives create a very high performance risk. Over time, knives become dull and make cutting difficult. As was seen in our prototype demo, the knives became dull over the course of the semester and created a huge safety issue during the cut. After sharpening the knives, the cut became easier and much of the safety concerns during the cut were alleviated. In order to keep this risk low, knives with more durable blades will be used. While this might increase the cost, safety and functionality are more important. Another source of risk is the number of parts and the machining needed to make the cutter. This creates a scheduling and cost issue. There are over 50 parts used in our prototype. Of these parts, over 20 of them require some form of machining. This increases the time and cost of manufacturing. By simplifying the design and having fewer machined parts, a lot of the scheduling and cost risk will diminish.

6 Working prototype

6.1 A preliminary demonstration of the working prototype (this section may be left blank).

6.2 A final demonstration of the working prototype (this section may be left blank).

6.3 At least two digital photographs showing the prototype

The following figures are of the final prototype.

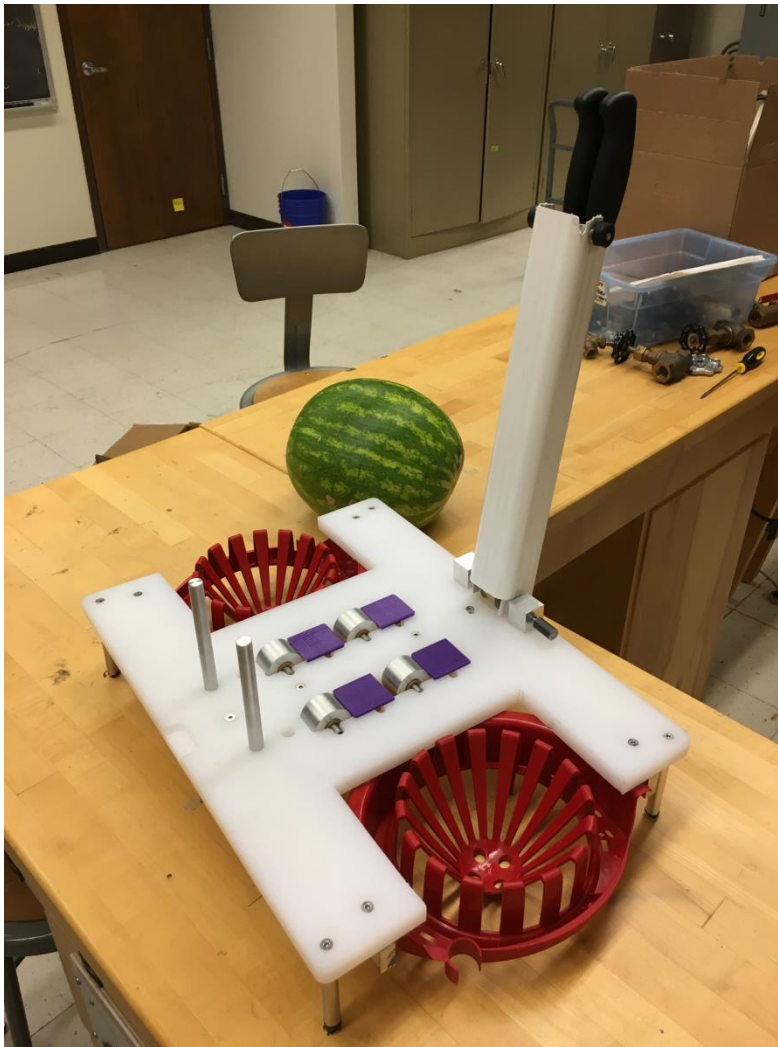


Figure 6.3.1- Final Prototype Assembled

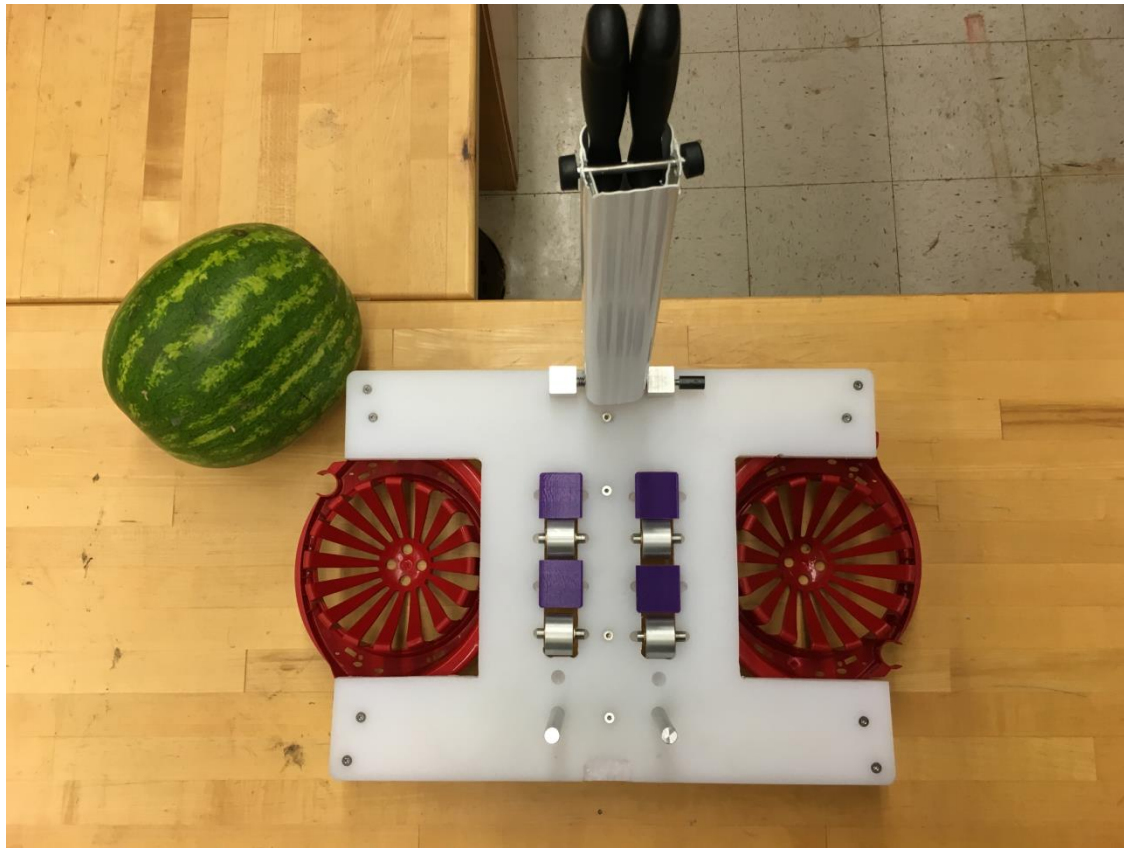


Figure 6.3.2- Top Down View of Final Prototype

6.4 A short videoclip that shows the final prototype performing

The URL here is a link to a video that shows the final prototype in action.

<https://www.youtube.com/watch?v=bZDiH670OXw>

6.5 Four Additional Photographs of the Final Prototype

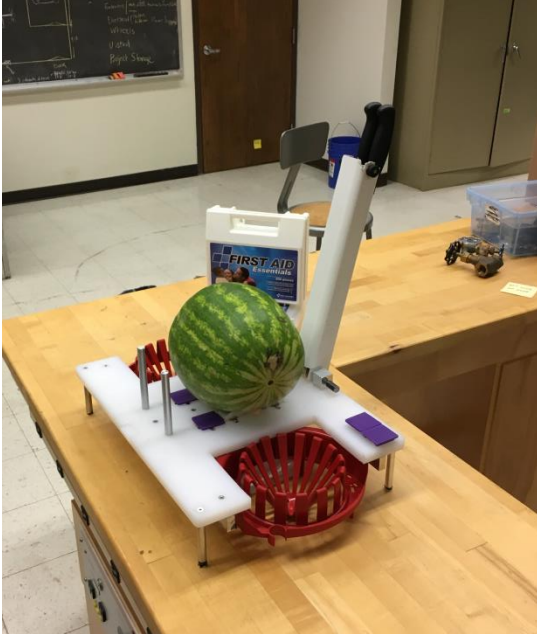


Figure 6.5.1- Prototype with Watermelon in Place for Cut

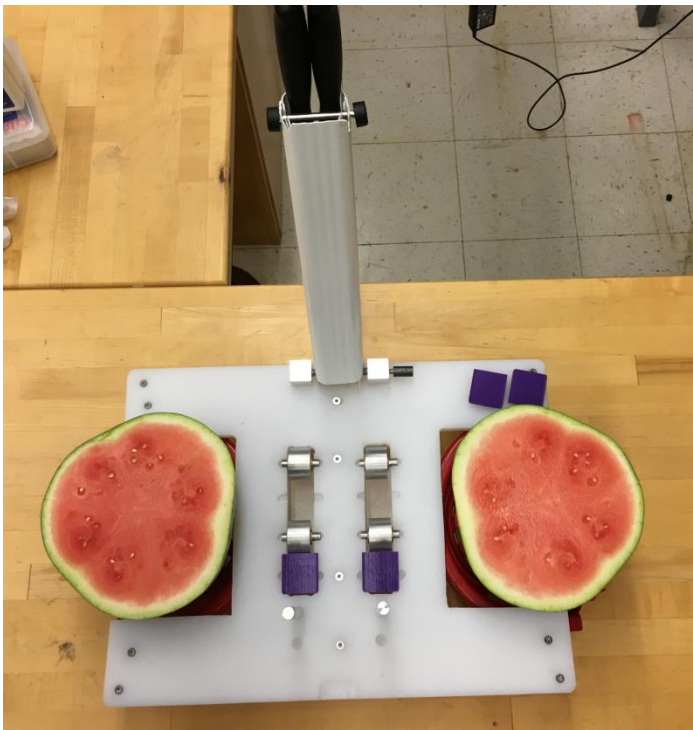


Figure 6.5.2- Bowls Holding the Halves after First Disk Cut



Figure 6.5.3- Cleanup After Cut: This paper towel was placed under the cutting board during the cutting and processing of the first disc. It is completely dry which shows how clean the cutting step is with this system.

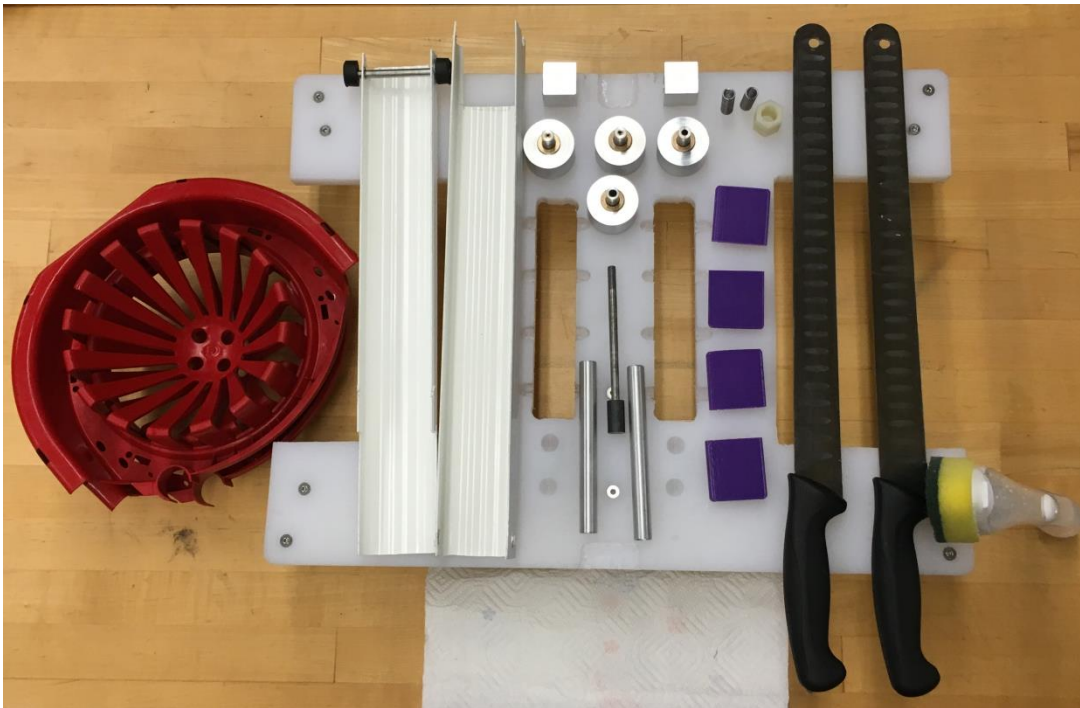


Figure 6.5.4- Prototype Disassembled for Cleaning

7 Design documentation

7.1 Final Drawings and Documentation

7.1.1 Final CAD Drawings

The final set of CAD drawings and drawings derived from CAD models can be found in Appendix C.

7.1.2 Sourcing instructions

The following table contains a complete list of materials and a method of sourcing each part. Some parts for this build were not purchased directly but found in the student machine shop and used with permission.

Table 7.1.2.1

Part Name	Quantity	Source
Cutting Board	1	Webstaurant Store: Full board purchased and modified in-house
Support Beam Type 1	2	McMaster-Carr: Aluminum stock purchased and cut to size with holes drilled/tapped
Support Beam Type 2	1	McMaster-Carr: Aluminum stock purchased and cut to size with holes drilled/tapped
Pillow Block Type 1	1	McMaster-Carr: Aluminum stock purchased and cut to size with hole drilled
Pillow Block Type 2	1	McMaster-Carr: Aluminum stock purchased and cut to size with hole drilled/tapped
Knife	2	Webstaurant Store: Knife purchased and modified in-house
Knife Shaft	1	McMaster-Carr: Steel Stock purchased and modified in-house
Spacer	2	McMaster-Carr: Two plastic nuts with proper inner diameter permanently fixed together
Bearing	8	McMaster-Carr
Roller Shaft	4	McMaster-Carr: Steel stock purchased and modified in-house
Roller	4	McMaster-Carr: Aluminum stock purchased and modified in-house
Leg	4	McMaster-Carr: Aluminum stock purchased and cut to size with holes drilled/tapped and rubberized coating added for 'feet'
Compressor Spring	2	McMaster Carr
Knife Shield 1	1	Home Depot: Plastic Downspout Extension purchased and modified in-house
Knife Shield 2	1	Home Depot: Plastic Downspout Extension purchased and modified in-house
Rubber Ends	2	Amazon.com: Rubber Amp/Cab Feet, Large Tapered w/ Washers- Purchased and press fit onto knife safety shaft
Knife Safety Shaft	1	McMaster-Carr: Aluminum stock purchased and cut to size
Watermelon Catcher	2	Home Depot: O-Cedar mop bucket purchased as donor for mop-wringing plastic insert, which is used as the catcher

Stoppers	2	McMaster-Carr: Aluminum stock purchased and cut to size
Covers/Caps	4	Designed with CAD software and 3D printed with ABS plastic

7.2 Final Presentation

7.2.1 Video Presentation

The following URL is for a video that contains the final presentation of this prototype given to the class and a panel of judges at the end of the semester.

<https://www.youtube.com/watch?v=fkguzVpTMNA>

7.3 Teardown

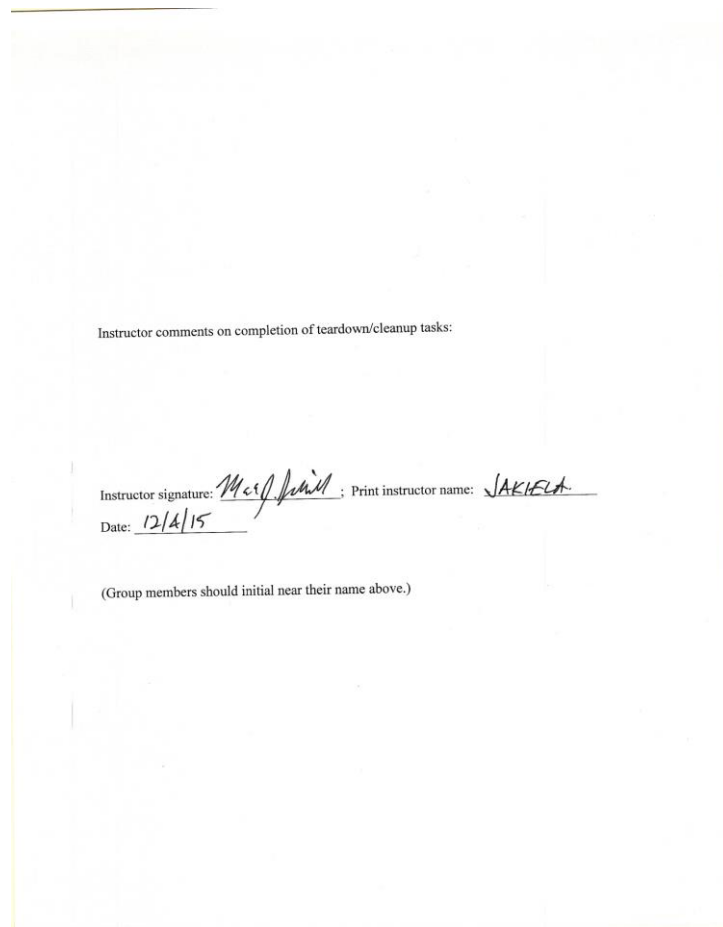
The following document describes the teardown process for this project.

TEARDOWN TASKS AGREEMENT

PROJECT: Watermelon I NAMES: Jack Welch INSTRUCTOR: Professor Jakiela
Eric Martel Eric Martel
Colin Lurie Colin Lurie
John Jakiela John Jakiela

The following teardown/cleanup tasks will be performed:

- Prototype will be disassembled and removed from school grounds.
- Each member will contribute to cleaning and organizing the student machine shop, where most of the work was completed throughout the semester.
- EVAE Jr 110.



Instructor comments on completion of teardown/cleanup tasks:

Instructor signature: [Handwritten Signature] : Print instructor name: JAKUBA

Date: 12/4/15

(Group members should initial near their name above.)

Figure 7.3.1- Teardown Document

8 Discussion

8.1 Evaluation of Quantified Needs Equations

After running the actual prototype through the quantified needs equations it scored about a 0.70. This score, while slightly lower than the estimated scores of the concepts, still justifies this choice. The sections that had the greatest influence on lowering the score would be number of assembly parts and weight. To make this prototype realizable within the time frame, we had to make parts for it in the most efficient way possible, which led to a large number of assembly parts. For example, each roller contains two bushings, a shaft and the roller. There are four rollers. We therefore have 16 assembly pieces for the rollers alone. Given more time and a higher budget, we could have created a more efficient roller system with far fewer pieces. The weight of the system also led to a lower score. Our prototype contains parts made of steel, aluminum and heavy plastics which contribute large weight additions. With a little refinement, we believe we would be able to reduce the weight of the system considerably.

The prototype scored well on the other aspects of the needs, however, including set up and clean up times, durability, cost and strength of the device.

8.2 Part Sourcing and Scrounging Issues and Recommendations

Our group was actually very lucky in that we did not encounter any major part sourcing issues. We ordered nearly all of our parts from McMaster-Carr and they arrived the same week. We estimated that it would be much more manageable for us to manufacture our parts rather than try to buy pre-existing parts and modify them to fit our design. We wound up scrounging very few parts that included our spacer for the knives, springs and some small screws. All of the scrounged parts we needed were readily accessible in the student machine shop. We therefore highly recommend buying stock from reputable vendors and for groups to attempt making their parts from this stock. During the design process we made very conscious decisions to make our parts easy to manufacture from existing stock. If future teams can manage to do the same, they too should have no problems in sourcing parts.

8.3 Discuss the overall experience:

8.3.1 Was the project more or less difficult than you had expected?

We agreed that the project was not more difficult than we expected, but much more time consuming than we expected.

8.3.2 Does your final project result align with the project description?

We are extremely pleased with how well the prototype aligns with the project description. All five of the requirements in the project statement posted are met. We even added some additional features such that the device can now accommodate a wide range of produce, it can break down for storage and cleaning and should be affordable enough for people to be interested in buying it.

8.3.3 Did your team function well as a group?

Our team functioned very well as a group. We all accepted the responsibilities that were assigned to us and everyone accomplished tasks in a timely manner. It was difficult at times for us to find consistent scheduling, but that is an inherent problem of group projects and not this particular group.

8.3.4 Were your team member's skills complementary?

We as a group were lucky in that each of the group members could function independently on the tasks that we needed to complete. Our prototype required considerable machining and fabricating. Everyone in our group, more or less, knew their way around the student machine shop. Anyone in the group could make any part we needed at any time and that greatly helped the project move forward since we were not reliant on one person's machining capabilities.

8.3.5 Did your team share the workload equally?

The team shared the workload equally. While we did not all work on the same task at the same time and split that task into four parts, we assigned tasks independently to the members. For example, one person would work on CAD drawings while another pieced together this report, etc. We found that in this fashion, we worked more effectively as a group and the project progressed at a reasonable pace.

8.3.6 Was any needed skill missing from the group?

We did not feel that any particular skill was missing from our group. If one member felt that they could not adequately perform a task, another member always could. There was not any major requirement for this project that we did not successfully meet as a group.

8.3.7 Did you have to consult with your customer during the process, or did you work to the original design brief?

We met with our customer only one time after we selected the design brief and that was for the user needs interview process. We gleaned what we could from the interview and worked toward the original design brief otherwise. We then worked the needs identified in the interview in to match the original design brief as best as we could. We were lucky that the needs identified by the customer complemented the original design brief so we did not have to sacrifice anything to fit one or the other.

8.3.8 Did the design brief (as provided by the customer) seem to change during the process?

The design brief only underwent minor changes during the process. It stayed consistent enough so that we did not need to scrap any ideas or concepts because they no longer applied to what the customer wanted. All of the changes in the design brief were identified during the user needs interview, which was early enough in the semester to avoid making large changes to the concepts.

8.3.9 Has the project enhanced your design skills?

We as a group feel that we are much more in tune with designing physically attainable concepts after this project. Some of the ideas we produced at the onset of this project would be very difficult to manufacture given our budget and time constraints. We also feel that we can more accurately design to specified needs identified by users of the product.

8.3.10 Would you now feel more comfortable accepting a design project assignment at a job?

We are much more knowledgeable about the entire design process after this project. We are more confident with identifying user needs and designing to those specifications. This project has also helped us learn to complete design tasks within budget and before deadlines which would be required for a job. There were also aspects that we were unfamiliar with at the beginning of the project, such as ordering parts in specific ways (as would be required for a job).

8.3.11 Are there projects that you would attempt now that you would not attempt before?

There are certainly projects that we would like to attempt that we would not attempt before. Since we are much more familiar with the entire design process, we feel that we could

successfully attempt more difficult design projects. Another aspect to consider would be utilizing different manufacturing methods to accomplish these designs. We were essentially restricted to manual lathes, mills and other standard machines. If we had access to some more advanced machines or services we could easily accept more difficult design projects.

9 Appendix A - Parts List

The table below lists the name and quantity of all the parts used in this prototype. The parts contained here are post modification from the parts we purchased or scrounged.

Part Name	Quantity
Cutting Board	1
Support Beam Type 1	2
Support Beam Type 2	1
Pillow Block Type 1	1
Pillow Block Type 2	1
Knife	2
Knife Shaft	1
Spacer	2
Bearing	8
Roller Shaft	4
Roller	4
Leg	4
Compressor Spring	2
Knife Shield 1	1
Knife Shield 2	1
Rubber Ends	2
Knife Safety Shaft	1
Watermelon Catcher	2
Stoppers	2
Covers/Caps	4
Screws, 10-32 1-1/4"	10
Screws, 10-32 1-.5"	10

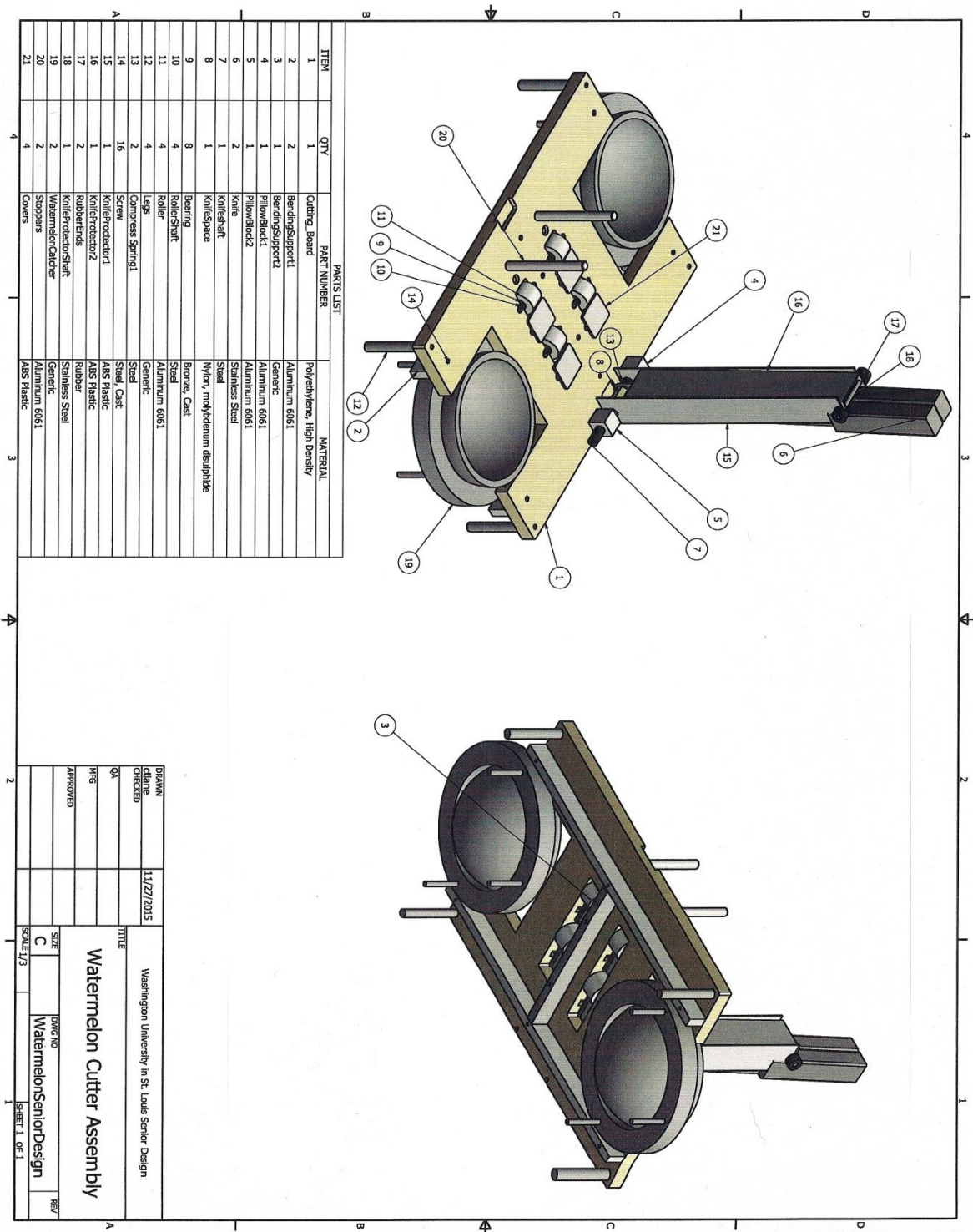
10 Appendix B - Bill of Materials

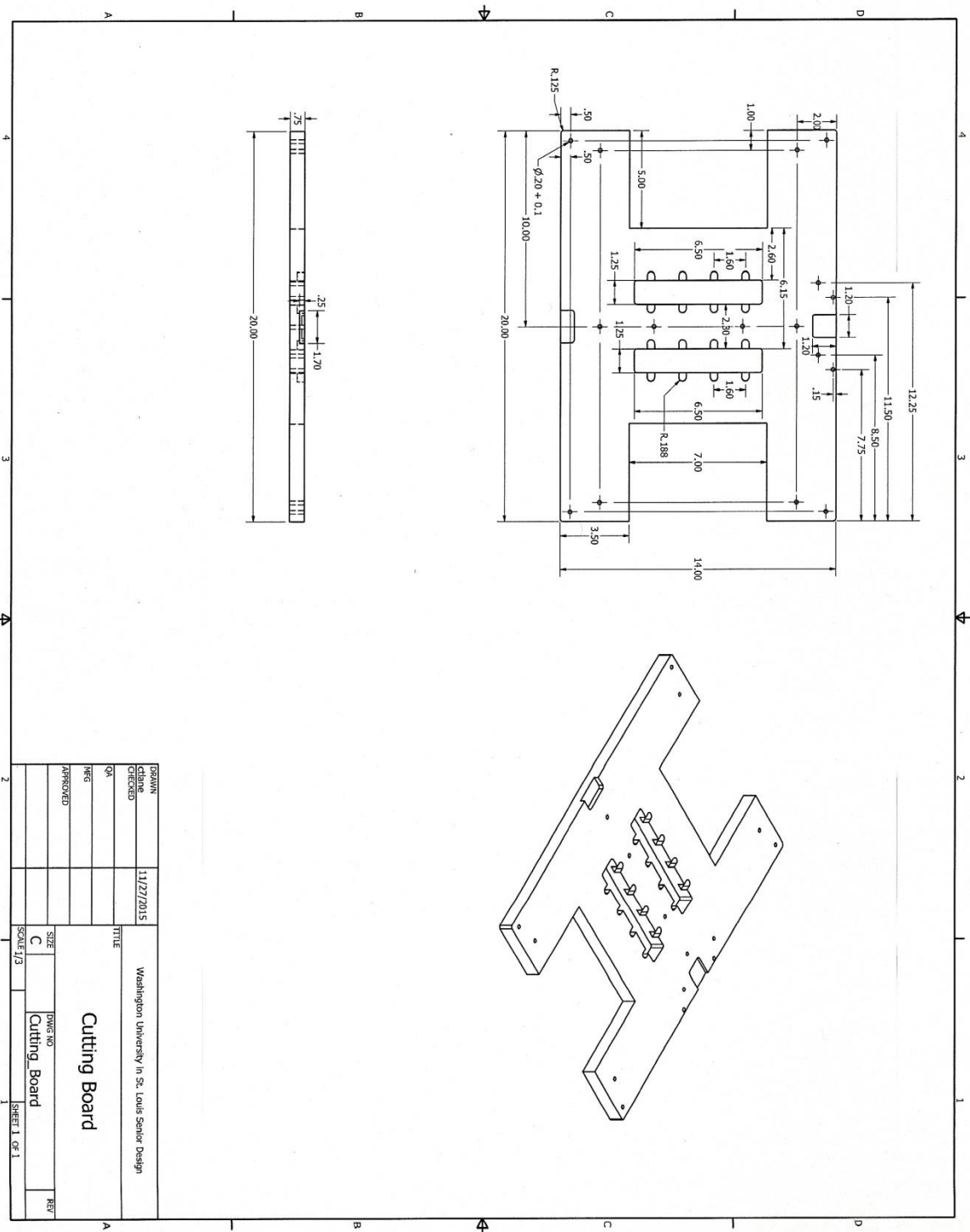
The table below lists the name of the part of the prototype and the material from which it came. That is to say that this list contains everything someone would need to replicate the prototype.

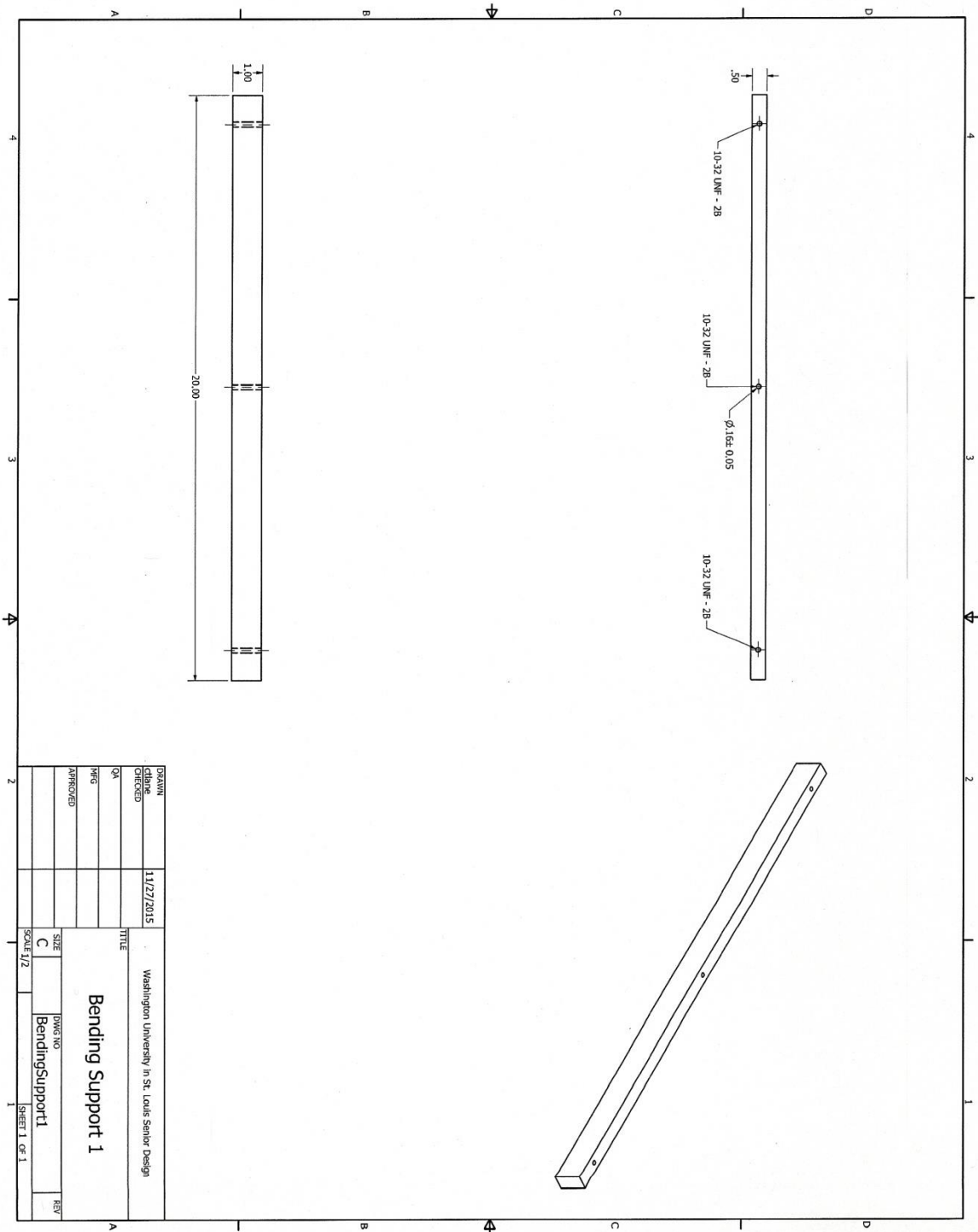
Part Name	Material
Cutting Board	15"x20"x3/4" Cutting Board
Support Beams, Type 1 and Type 2	Aluminum Stock: 48" long by 1"x0.5"
Pillow Blocks, Type 1 and Type 2	Aluminum Stock: 1.25"x2.25"x1.25"
Knife	Mercer Produce Knife
Knife Shaft	Steel Stock: 6" long x 0.5" diam.
Spacer	Plastic Nuts: 1.2" Inner diam.
Bearing	Brass Bushings, 0.375" Inner diam.
Roller Shaft	Steel Stock: 12" long by 0.375" diam.
Roller	Aluminum Stock: 12" long by 1.5" diam.
Leg	Aluminum Stock: 2' long by 0.5" diam.
Knife Shields 1 and 2	15" Plastic Downspout Extension
Rubber Ends	Rubber Amp/Cab Feet, Large Tapered w/ Washers
Knife Safety Shaft	Aluminum Stock: 6" long, 1/4" diam.
Watermelon Catcher	Mop Wringer Inserts
Stoppers	Aluminum Stock: 12" long, 1/2" diam.
Covers/Caps	3D Printed ABS Plastic
Screws	10-32 1-1/4"
Screws	10-32 1-.5"

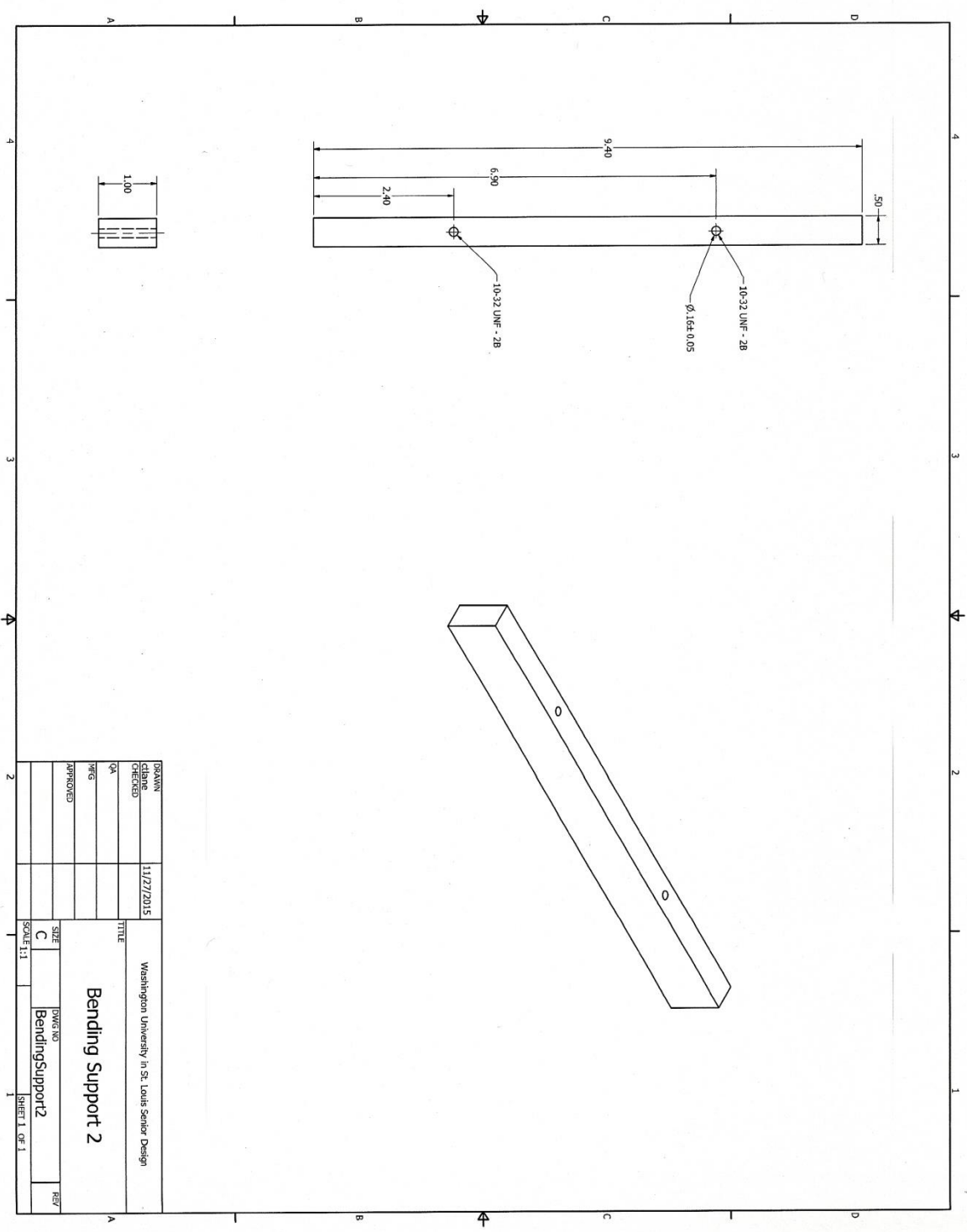
11 Appendix C - CAD Models

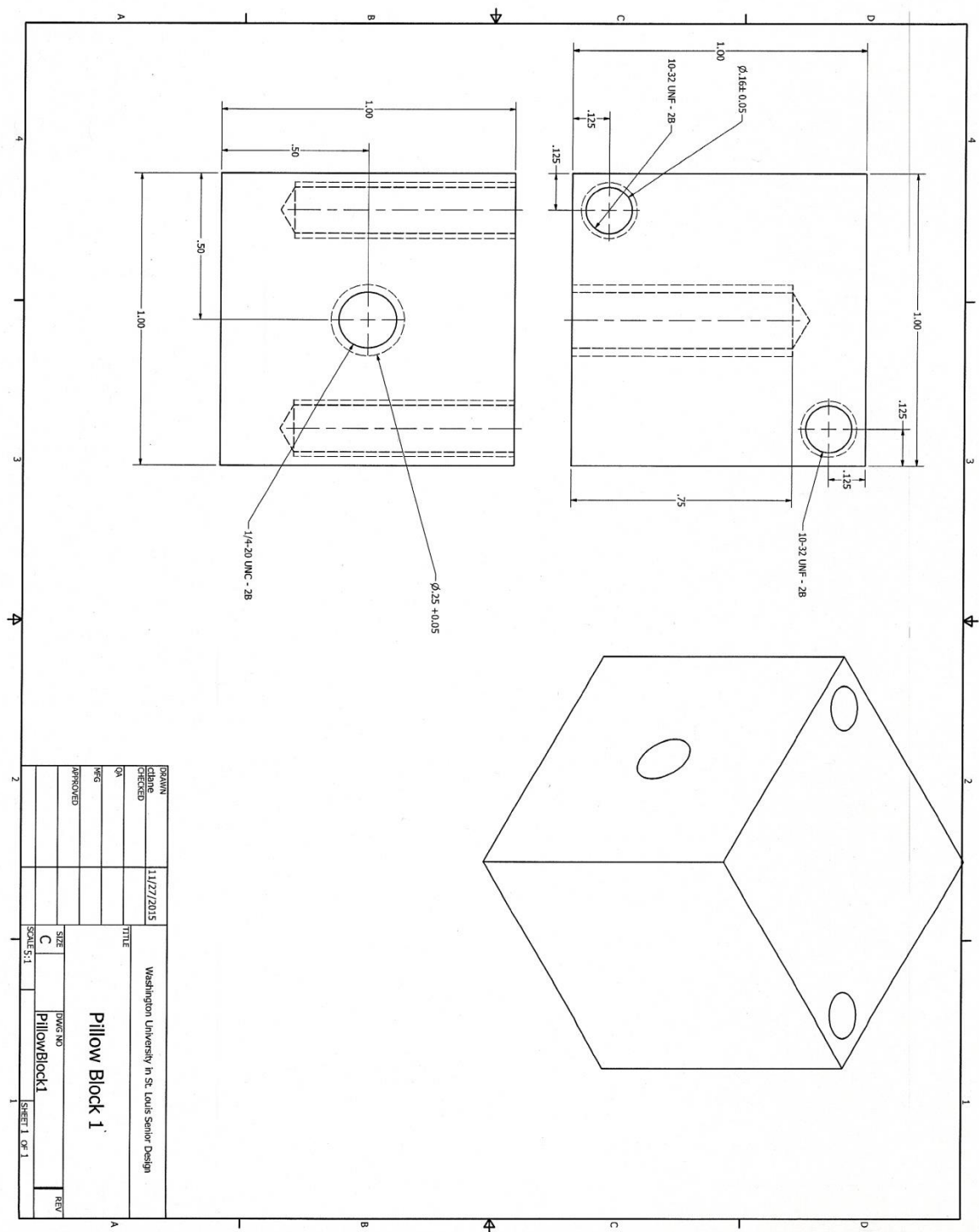
The following figures are the final CAD models of the prototype.

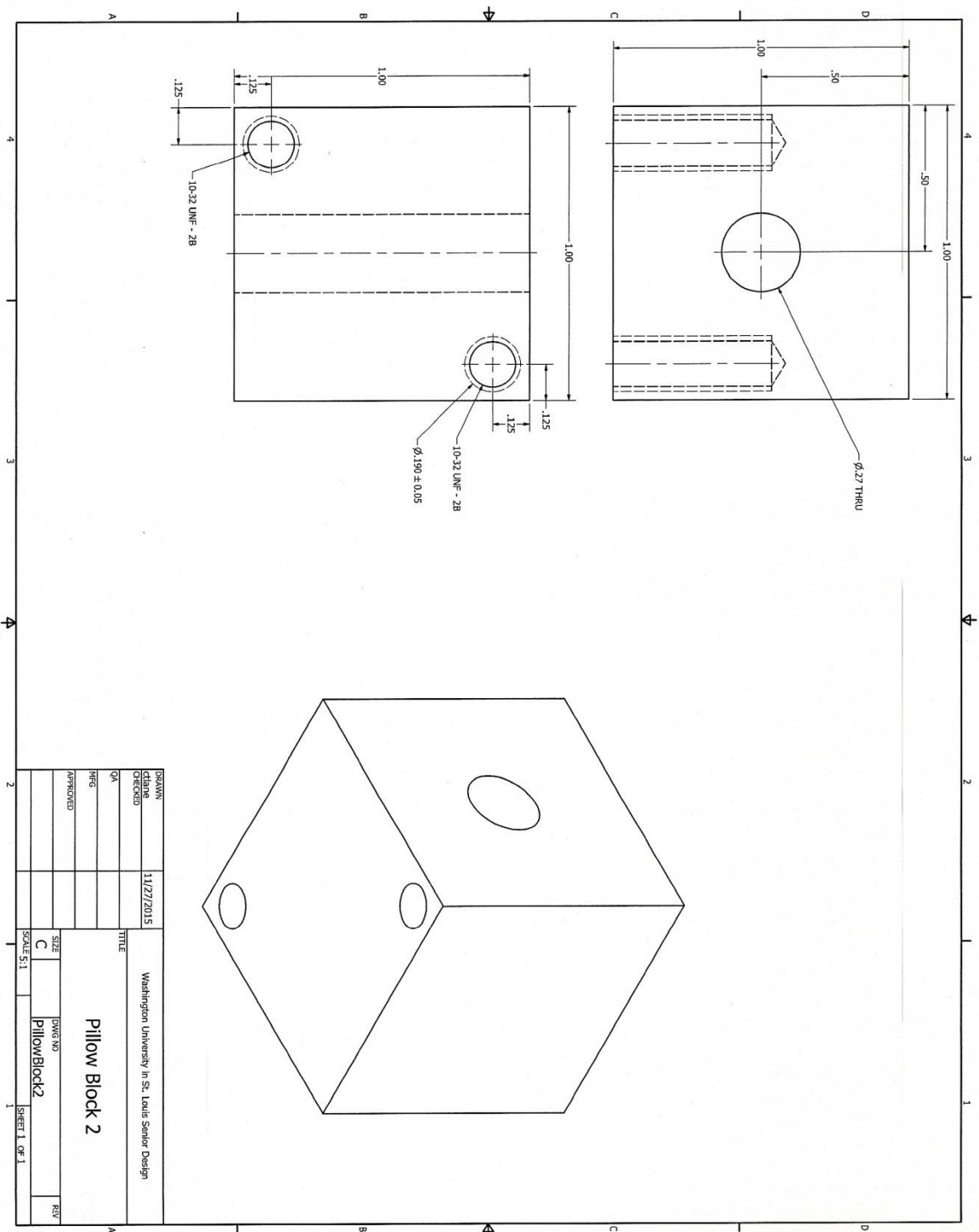


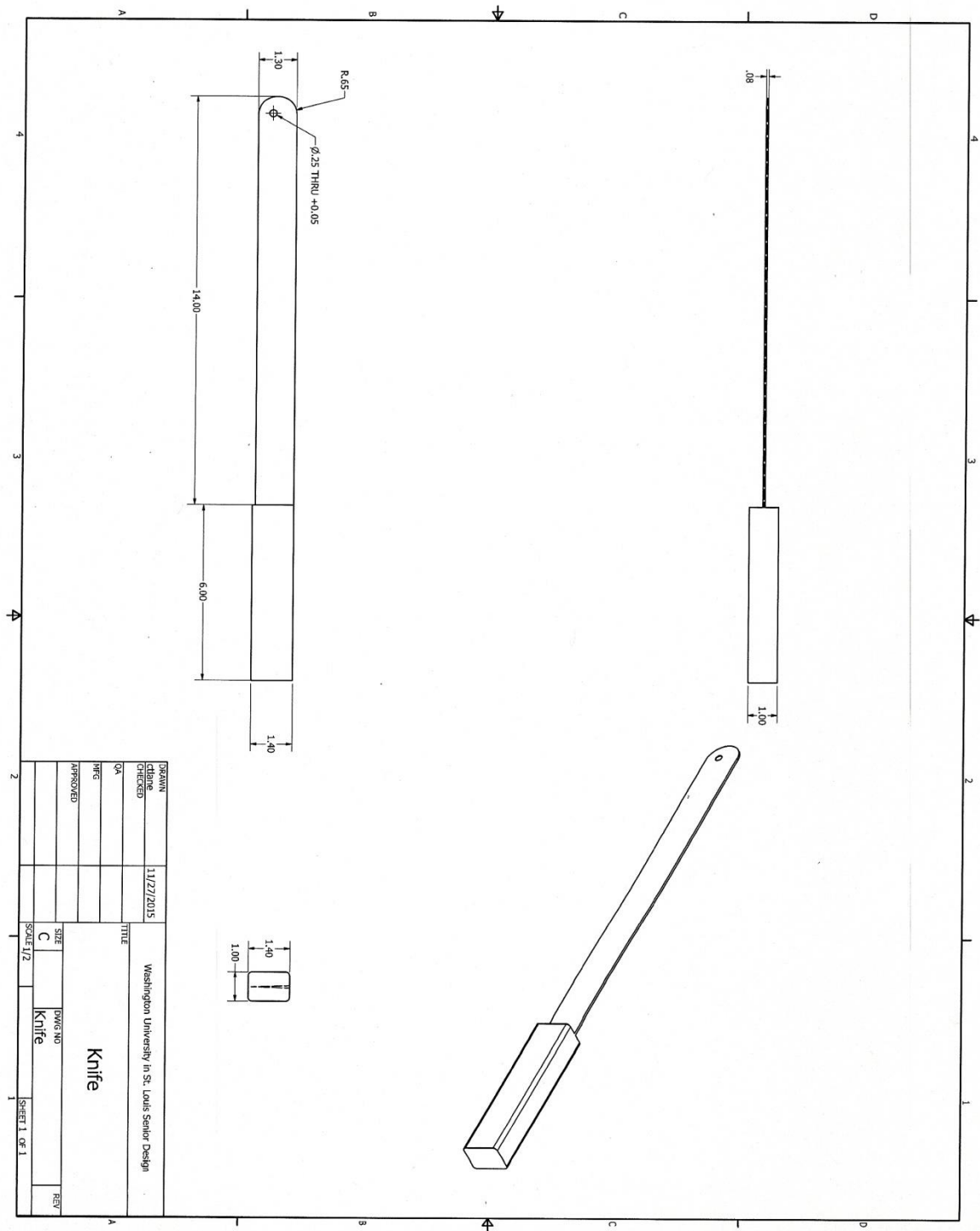


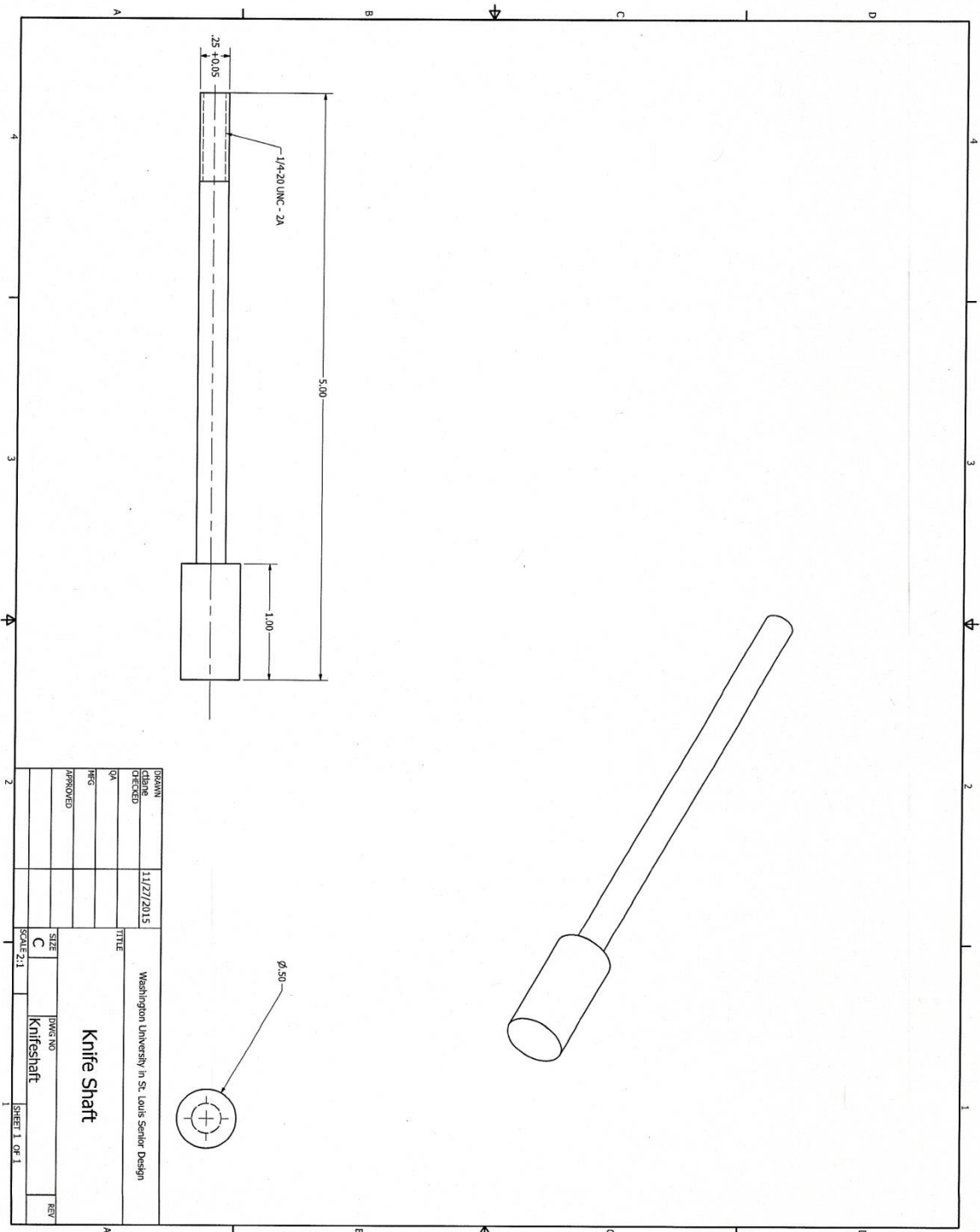


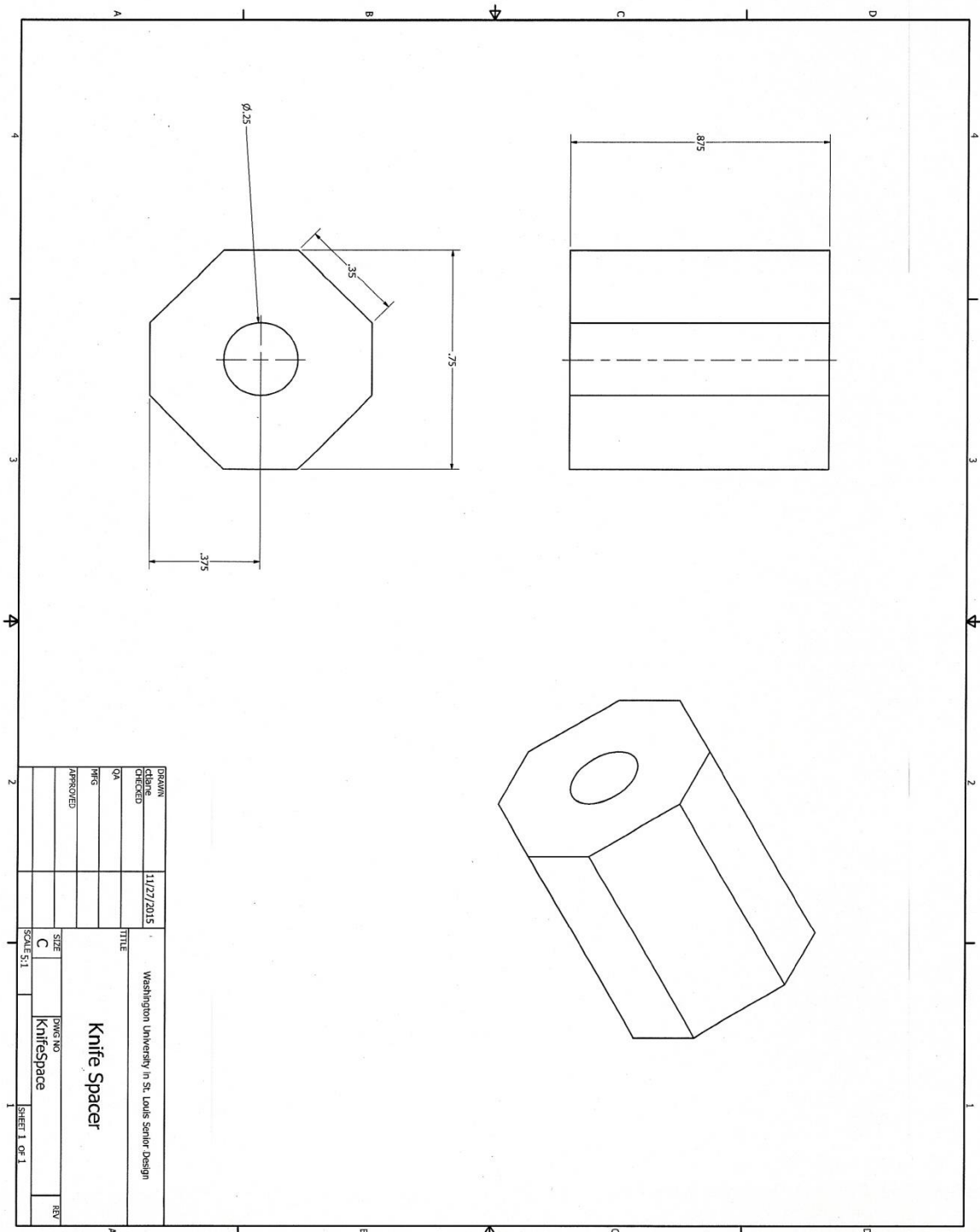


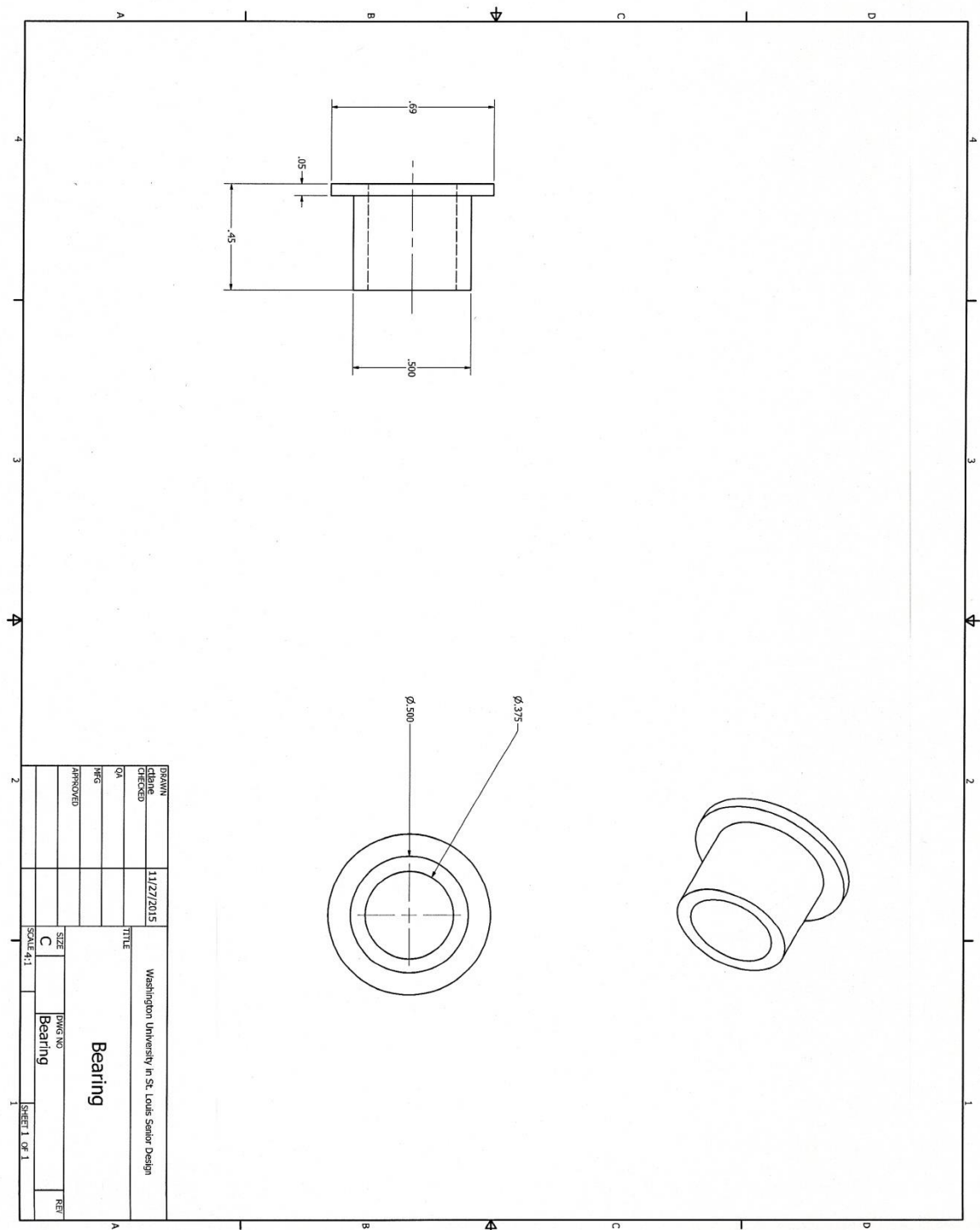


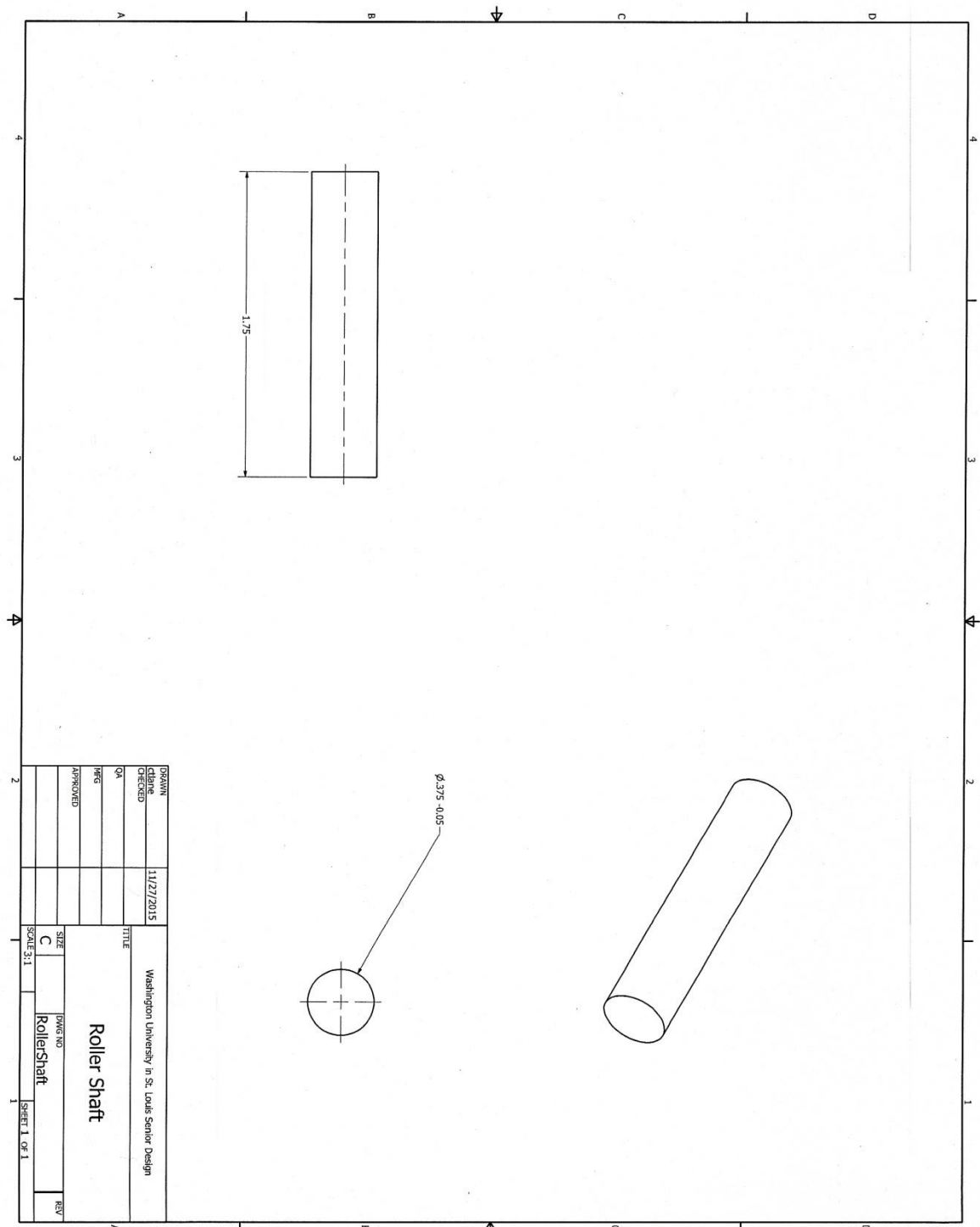


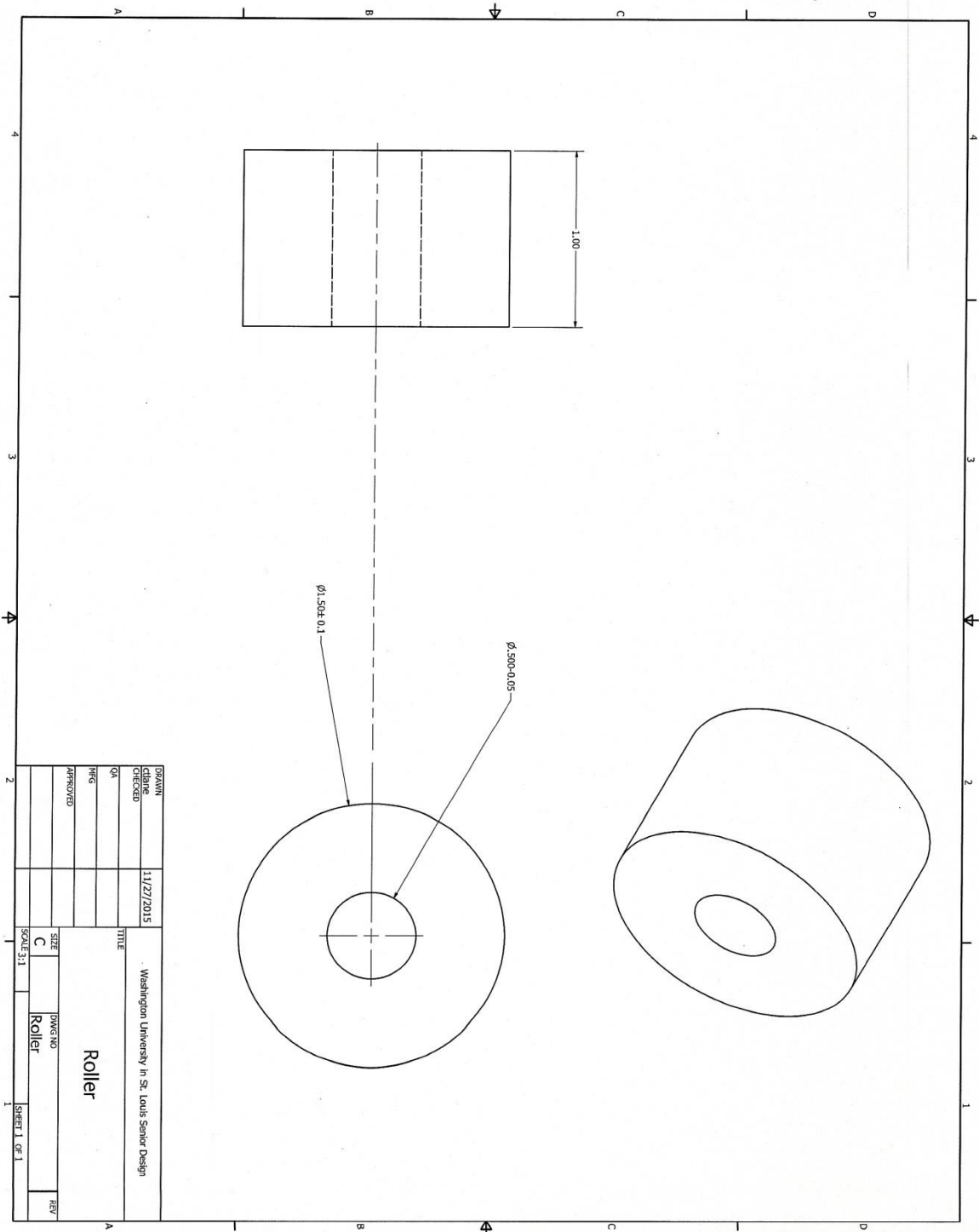


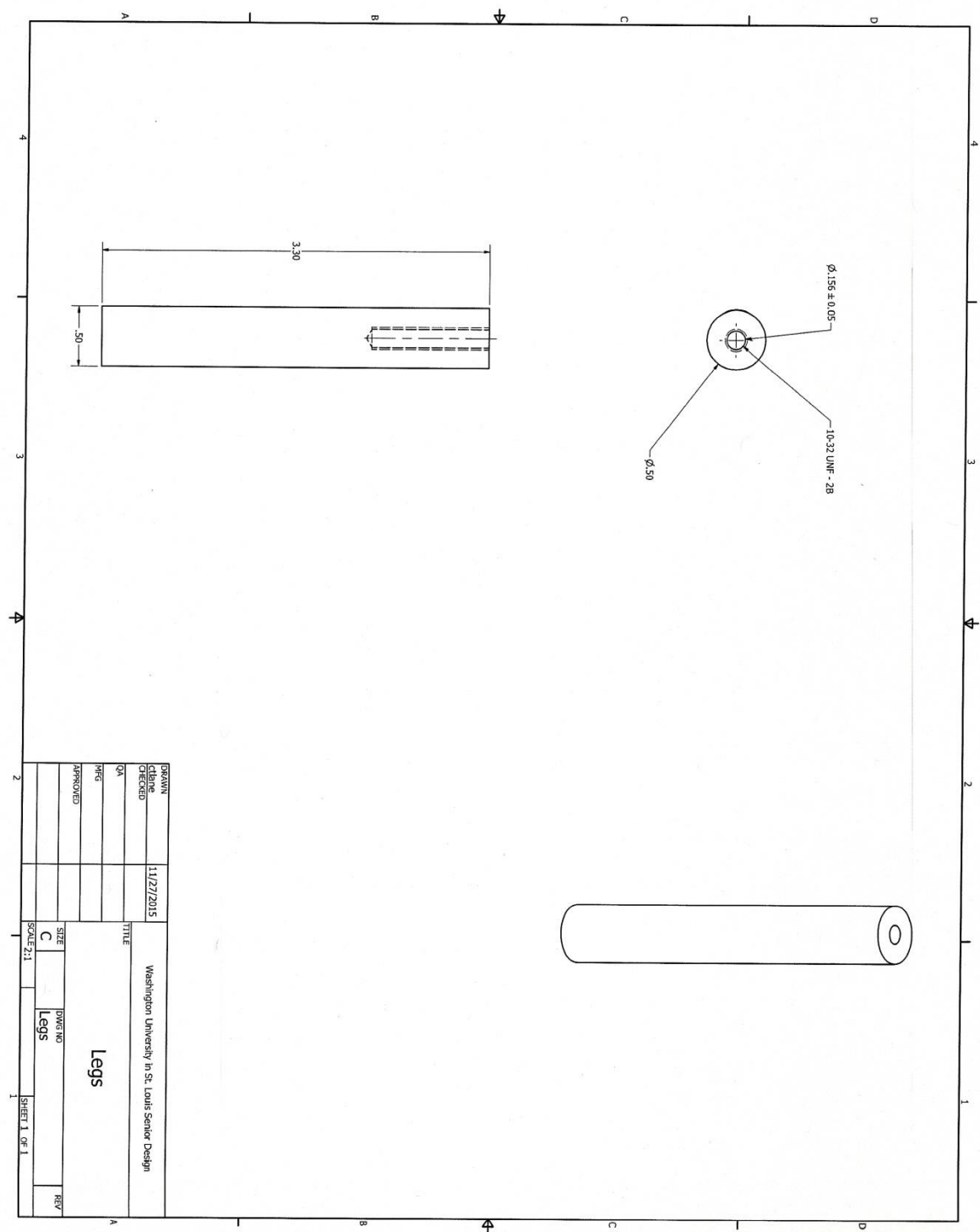


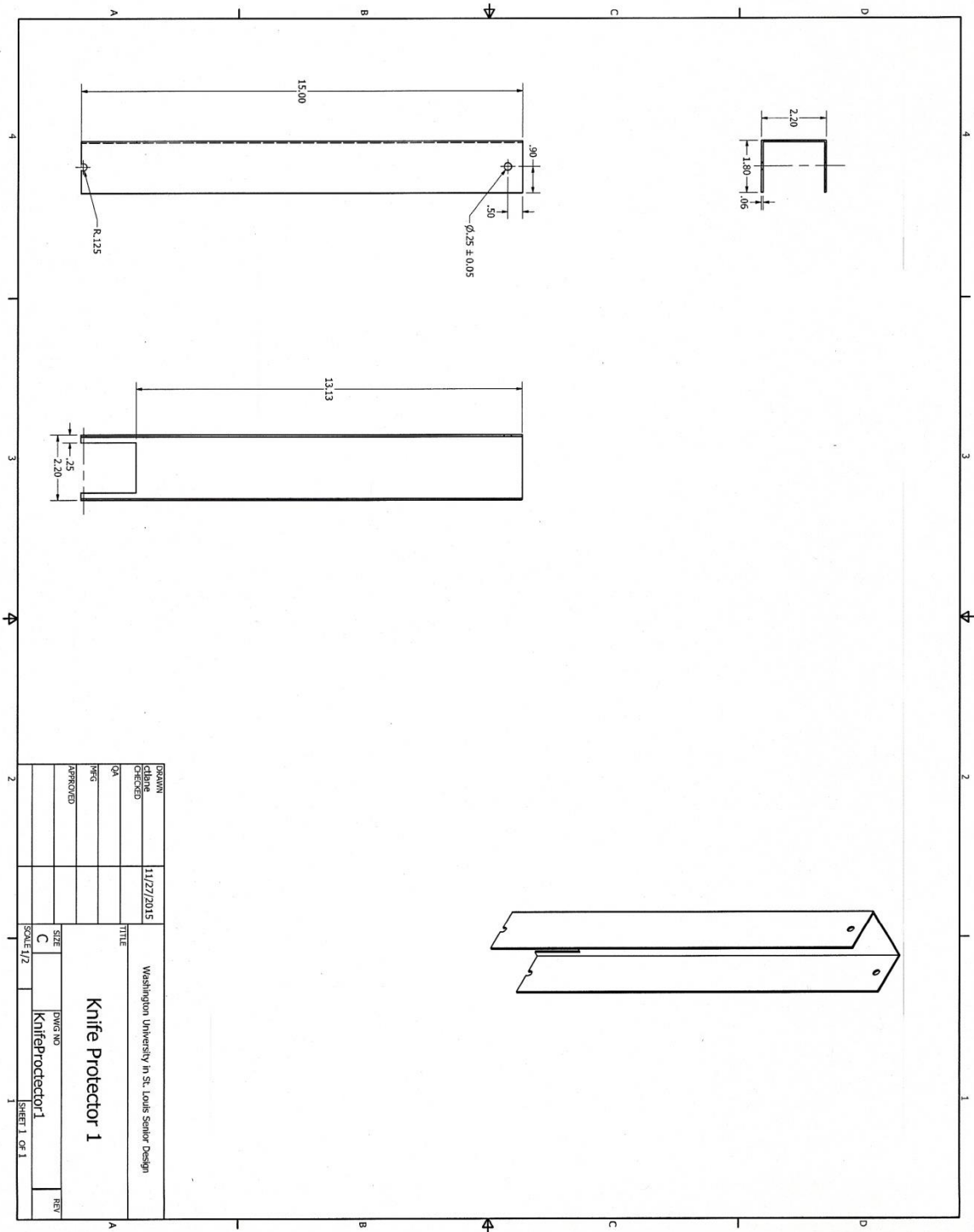


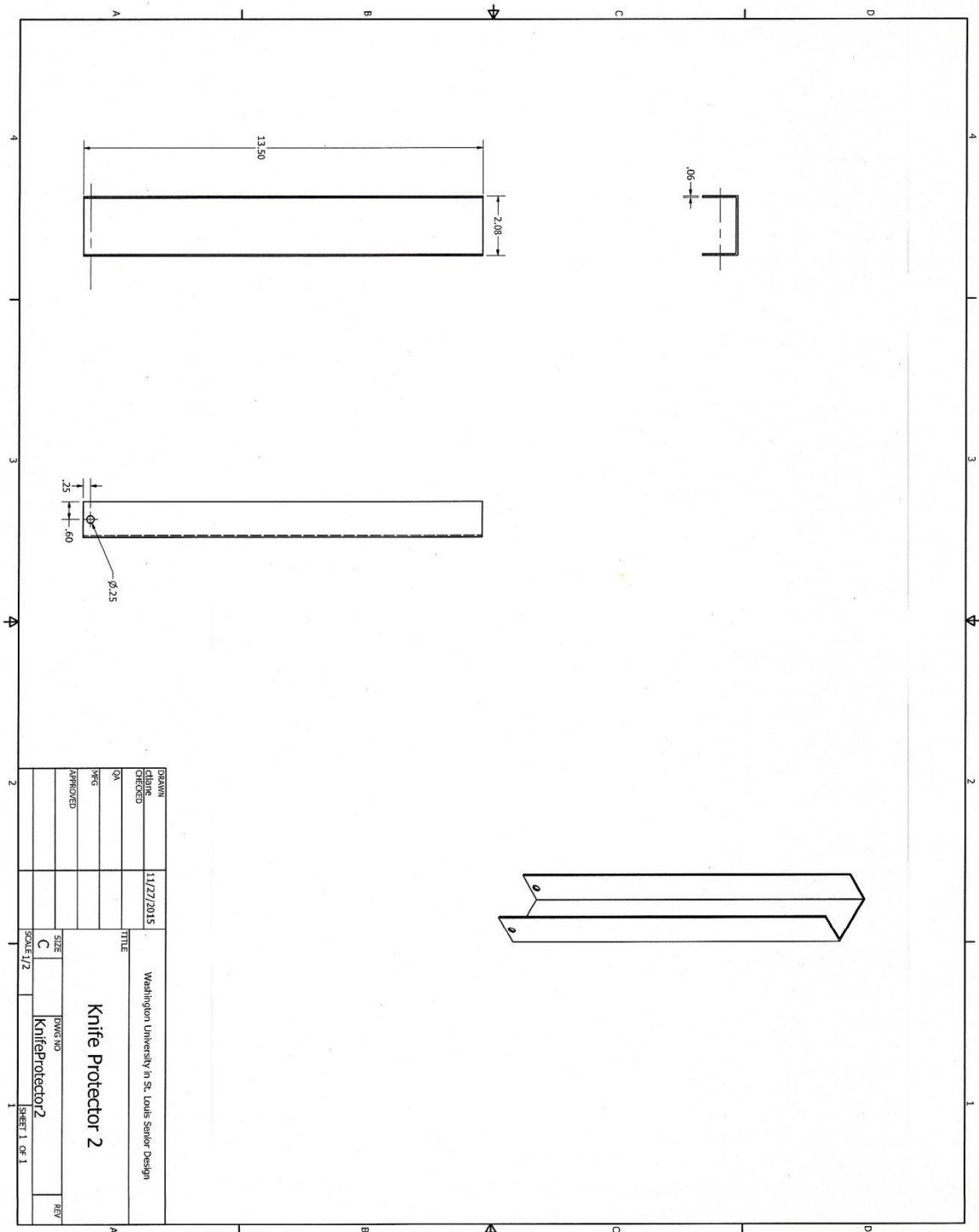


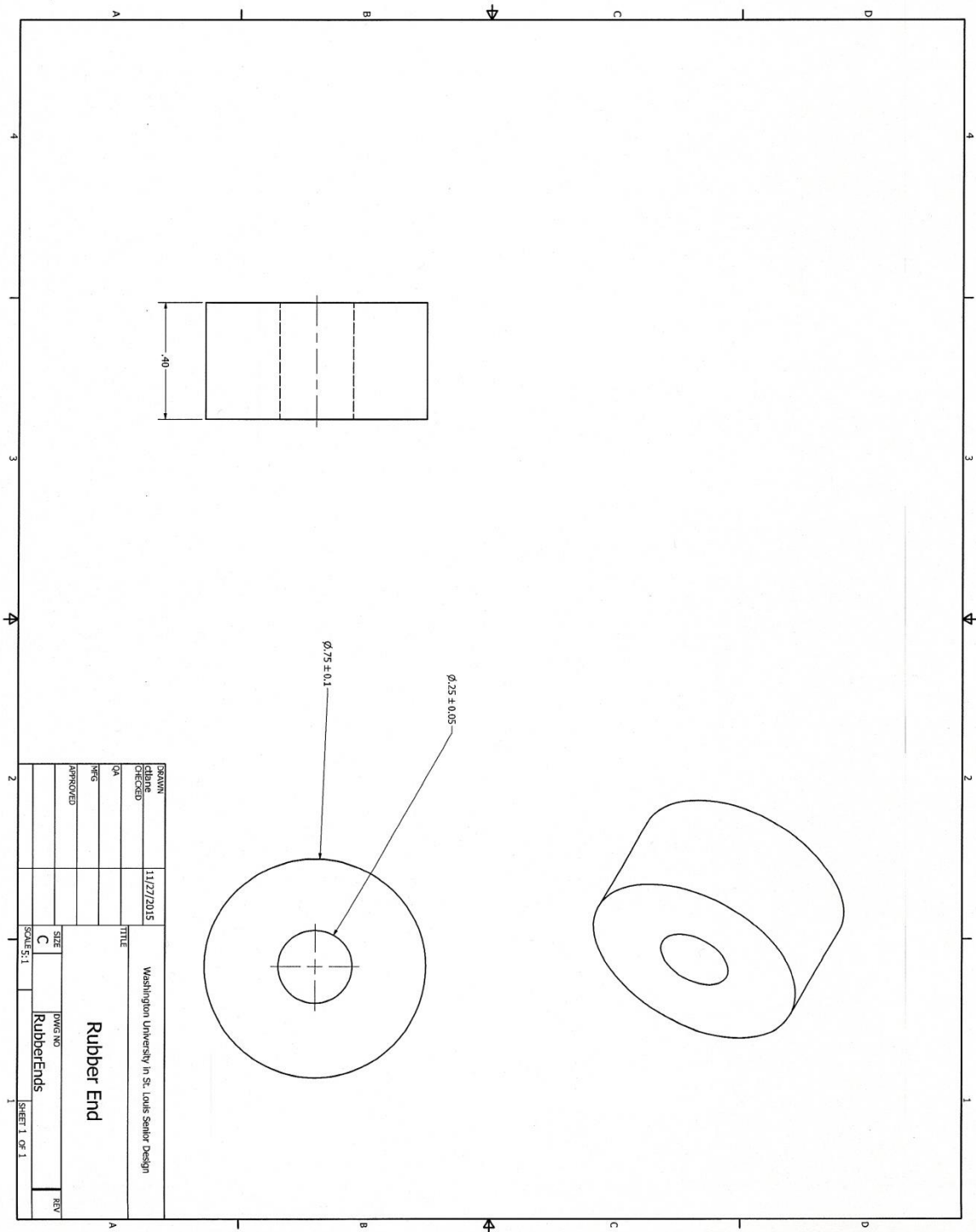


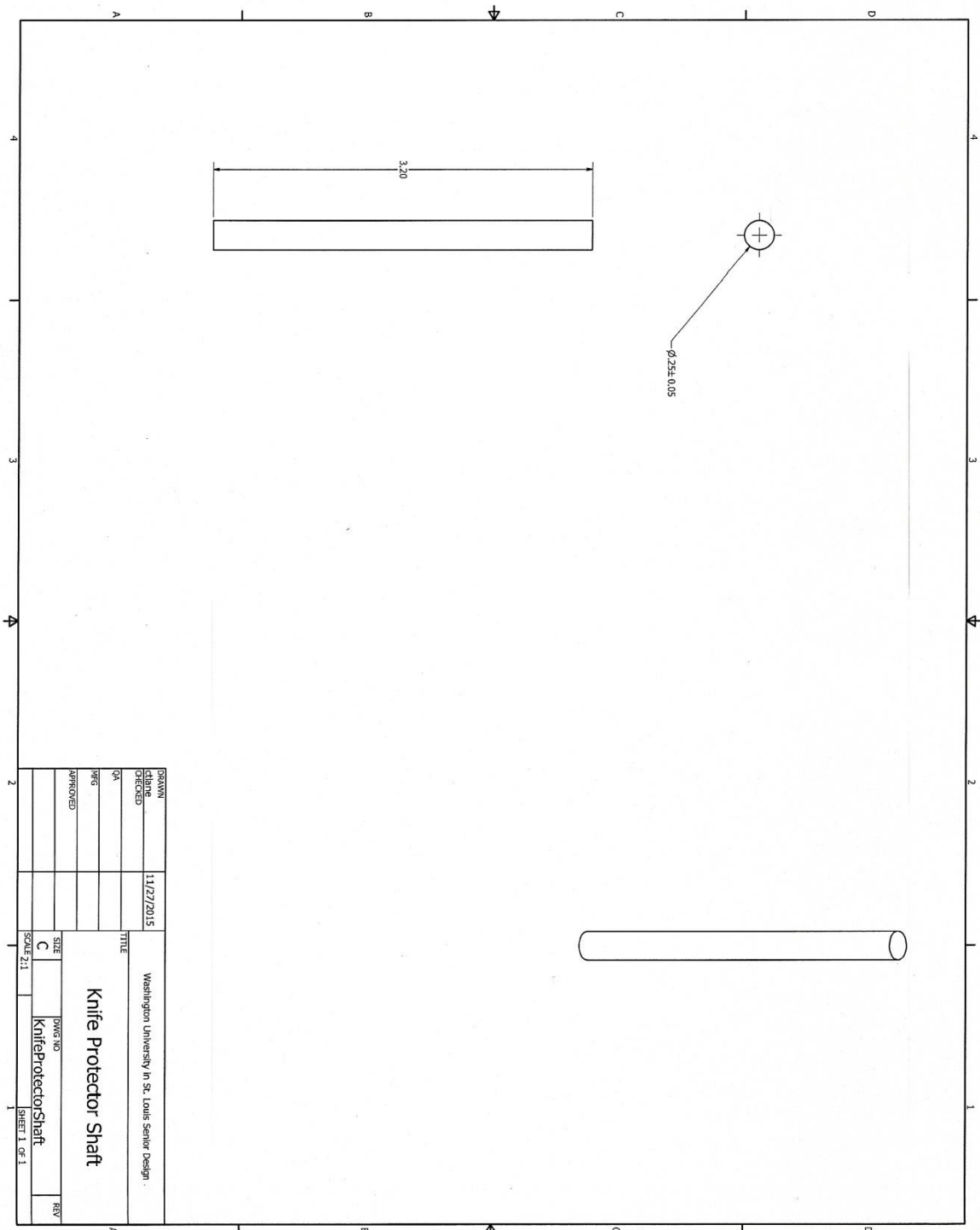


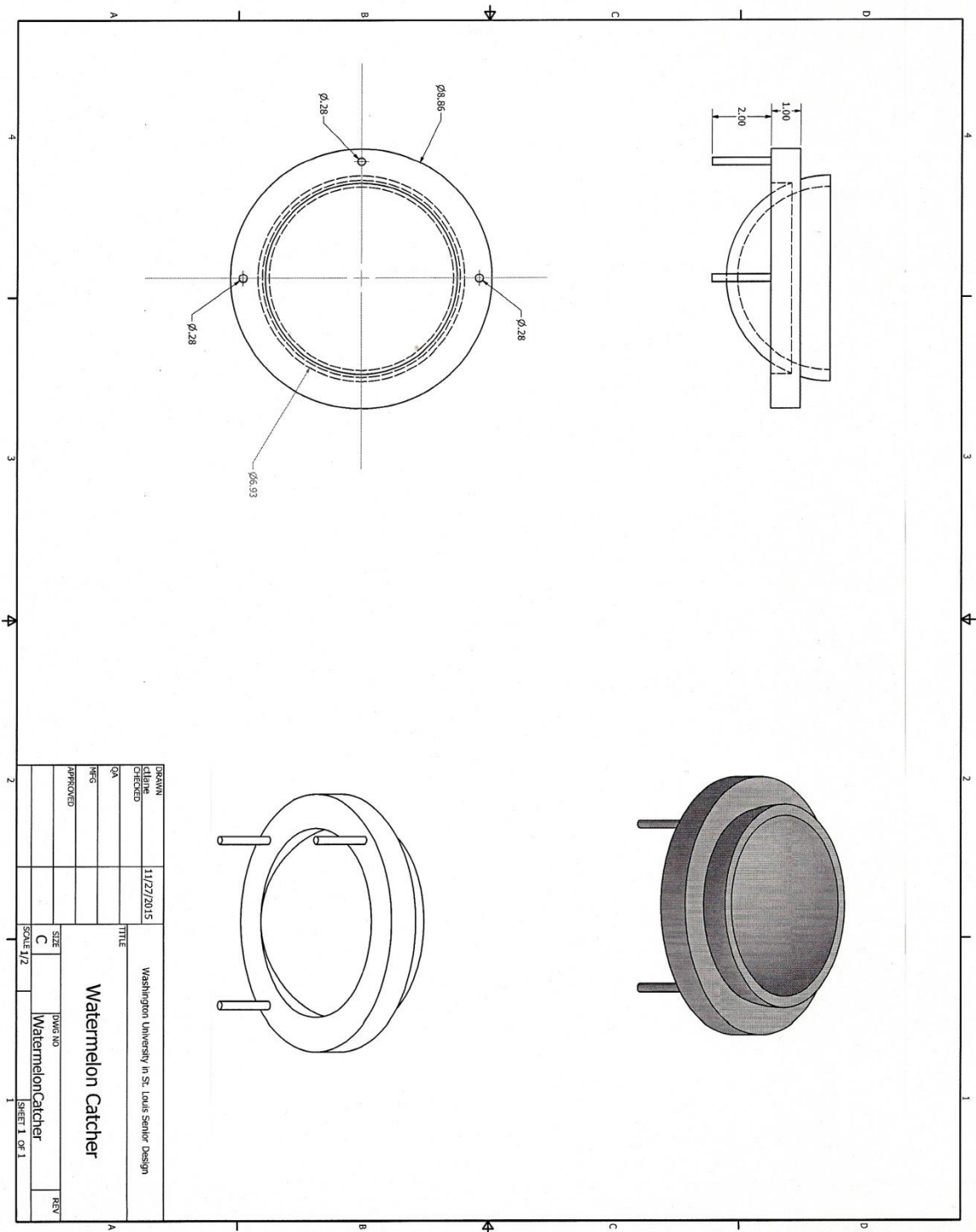


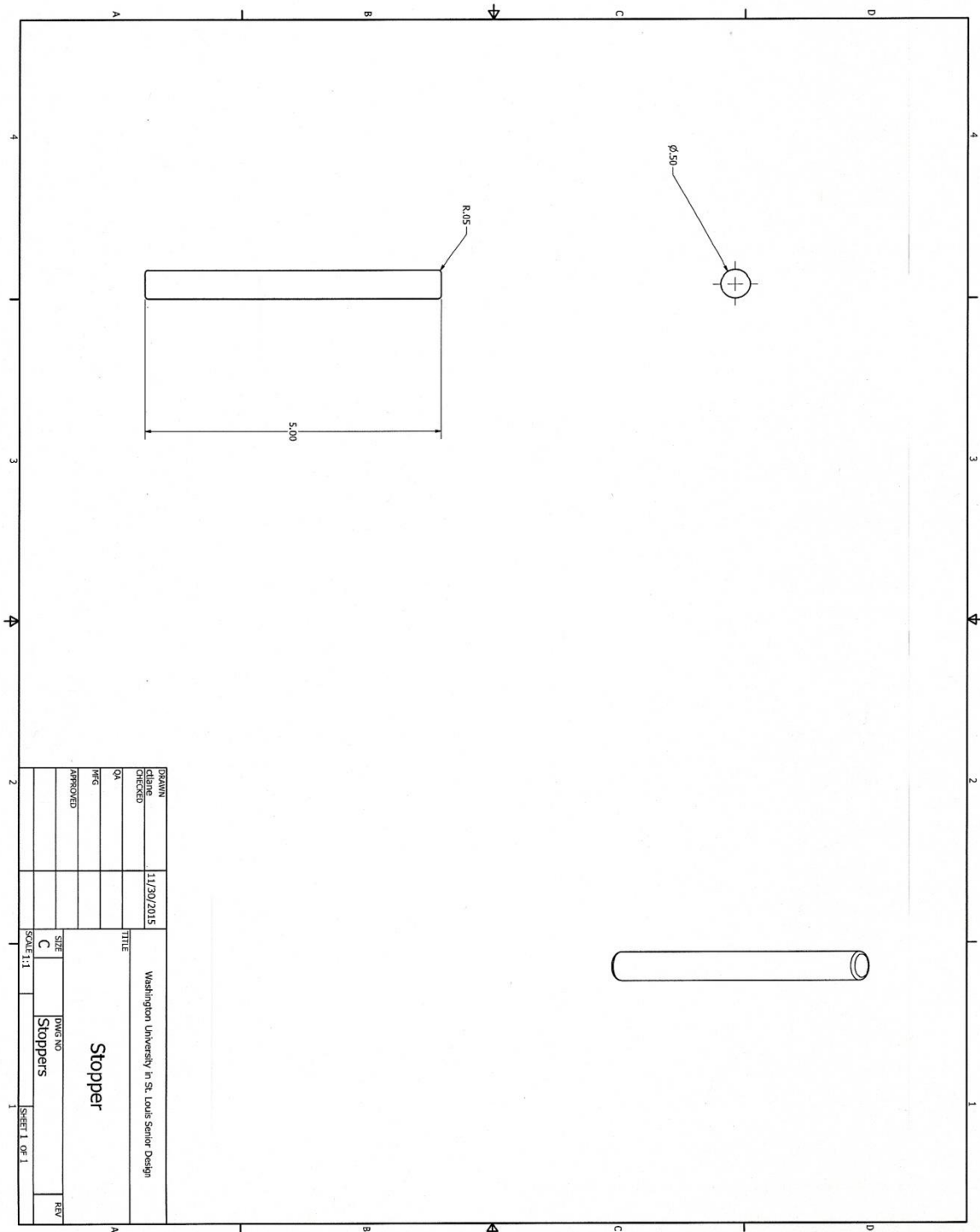


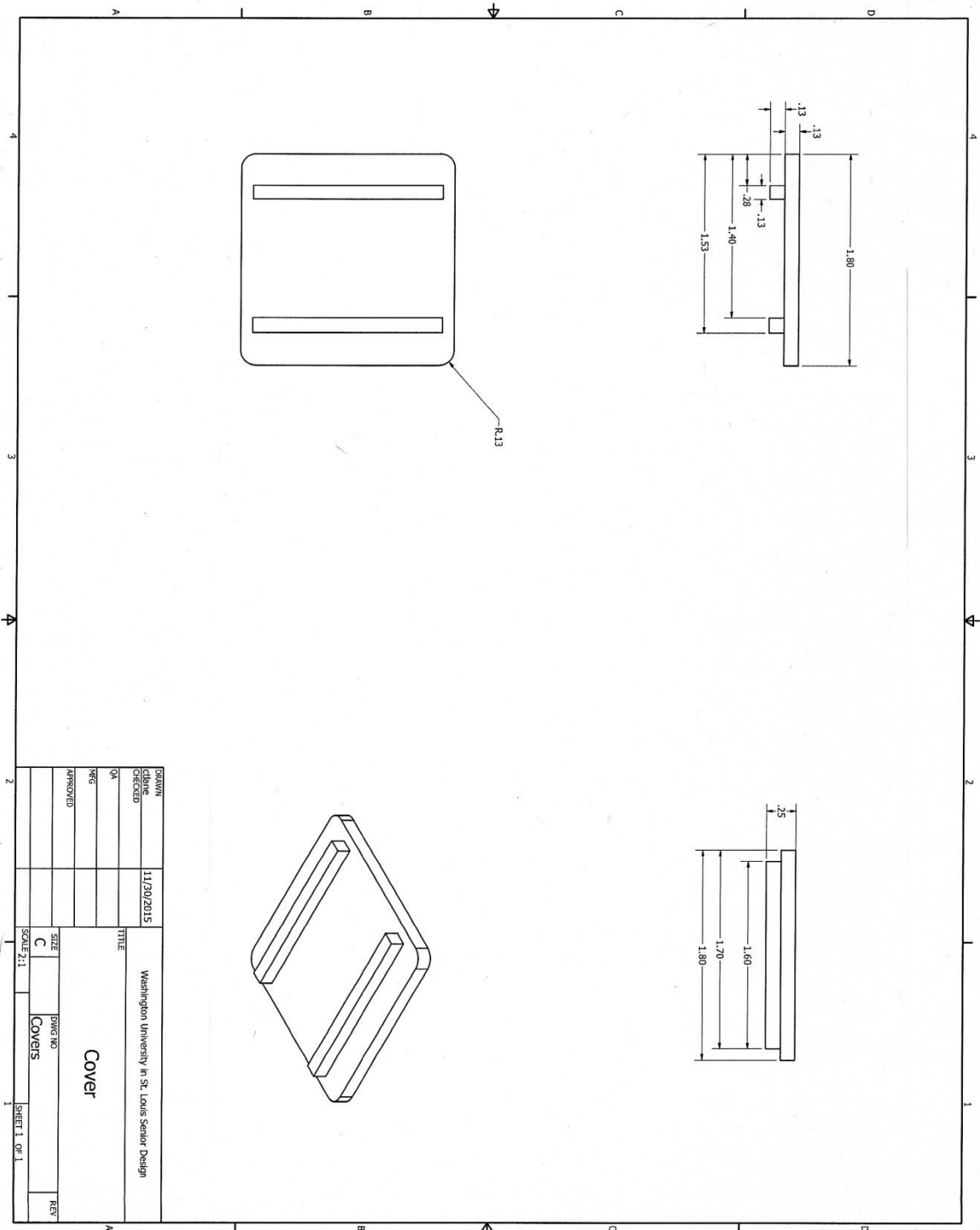












12 Annotated Bibliography

Relevant URL's have been provided along in each corresponding section.

- Section 2.2 contains the patent references
- Section 5.2.6 contains the standards and codes references we used

The Risk assessment was done with the following information from MITRE:

- <http://www.mitre.org/publications/systems-engineering-guide/acquisition-systems-engineering/risk-management>

The engineering analysis was completed with the use of the following:

- Hibbeler, R.C. "Statics and Mechanics of Materials." 4th ed., Pearson Prentice Hall, 2014.
Section 11.3 for deflection of bending of a beam and 17.3 for buckling